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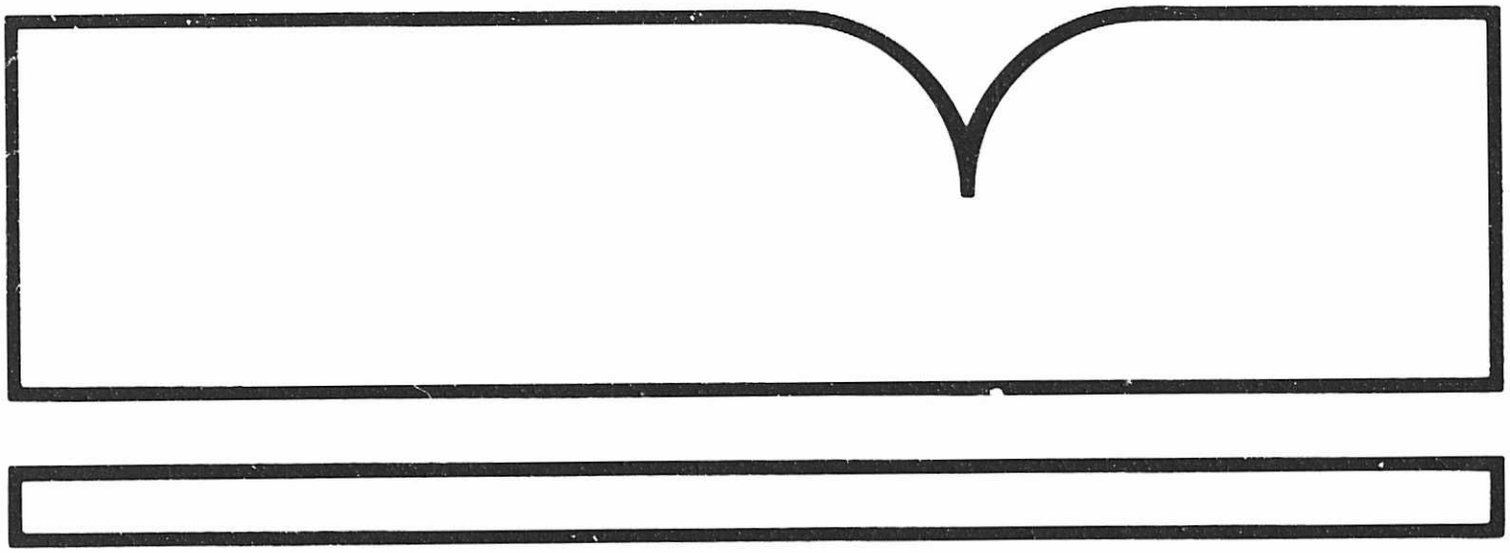
PB92-163104

NASA Excellence Award for Quality and Productivity 1989 Highlights 1989 Recipient: Lockheed Engineering and Sciences Company

(U.S.) National Aeronautics and Space Administration, Washington, DC

Apr 90



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Abstract: The NASA Excellence Award for Productivity and Quality is the result of NASA's desire to encourage superior quality and the continuous improvement philosophy in the aerospace industry. It is awarded to NASA contractors, subcontractors, and suppliers who have demonstrated sustained excellence, customer orientation, and outstanding achievements in a total quality management (TQM) environment. The 'highlights' booklet is intended to transfer successful techniques demonstrated by the performance and quality of major NASA contractors.

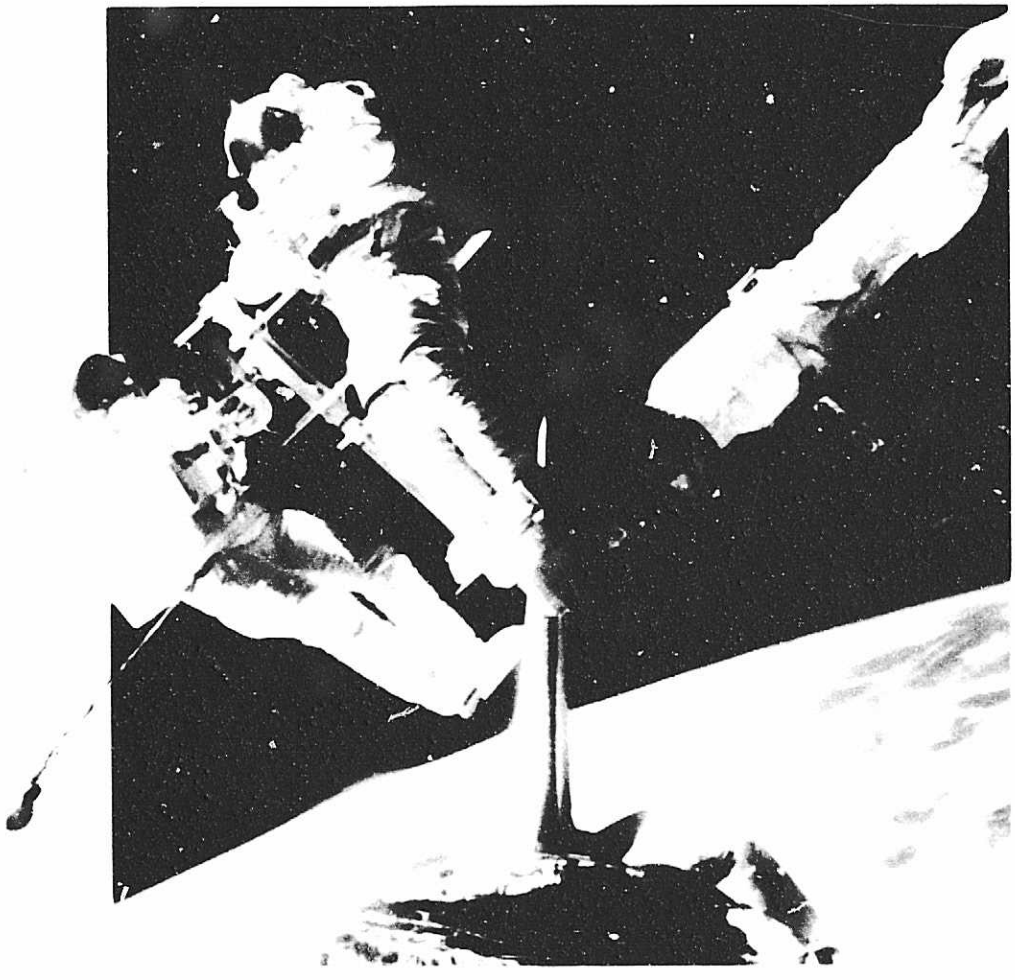
HIGHLIGHTS

PB92-163104

1989

NASA Excellence Award

for Quality and Productivity



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SPRINGFIELD, VA 22161

1989

NASA Excellence Award

for Quality and Productivity

1989 Recipient

Lockheed Engineering & Sciences Company

Sponsored by the
National Aeronautics and Space Administration
Office of Safety, Reliability, Maintainability and Quality Assurance, NASA Quality and Productivity Improvement Programs

with the assistance of the
American Society for Quality Control

April 1990

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The truly successful quality process has commitment and involvement from top to bottom. At LESC ESPO, this starts at the top with its president and chief executive officer, R. B. "Bob" Young.

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I N T R O D U C T I O N

The NASA Excellence Award for Quality and Productivity is the result of NASA's desire to encourage superior quality and the continuous improvement philosophy in the aerospace industry. It is awarded to NASA contractors, subcontractors, and suppliers who have demonstrated sustained excellence, customer orientation, and outstanding achievements in a total quality management (TQM) environment. The objectives of this award are to:

- increase public awareness of the importance of quality and productivity to the nation's aerospace program and industry in general;
- encourage domestic business to continue efforts to enhance quality, increase productivity, and thereby strengthen competitiveness;
- provide the means for sharing the successful methods and techniques used by the applicants with other American enterprises.

We believe this award process, now beginning its fifth year, has clearly demonstrated benefits that can be derived by participating in the program. It provides an unequalled learning environment for those organizations seeking to improve the quality and productivity of their products and services. It is particularly exciting to acknowledge in this publication the accomplishments of the first service/support organization to be the award recipient, LESC ESPO.

This "Highlights" booklet is intended to transfer successful techniques demonstrated by the performance and quality of work accomplished by Lockheed Engineering & Sciences Company. The booklet, aligned with seven strategies developed by NASA and its contractor team, details Lockheed's efforts in achieving outstanding performance and customer satisfaction. NASA urges other aerospace companies to emulate and tailor to their needs the successful methods and programs highlighted in this booklet.

Joyce R. Jarrett, Director
NASA Quality and Productivity
Improvement Programs

F O R E W O R D

Quality is vital to the space program and requires continuous commitment by the NASA Contractors Team to build quality and reliability into our products and services. To further these aims, NASA annually presents the NASA Excellence Award for Quality and Productivity to those NASA aerospace companies—both large and small—whose products exemplify the highest standards of performance. The award recognizes organizations that seek continuous improvement and demonstrate an adherance to the tenets of Total Quality Management.

I wish to thank all the contractors that applied for the Excellence Award, and my special congratulations to Lockheed Engineering & Sciences Company—the award recipient for 1989. NASA is committed to working with its contractors to achieve excellence. Those NASA companies that apply for NASA's most prestigious award, and progress through the rigid examination process, show us they are committed to excellence. It is this type of dedication that will enable this country to remain a competitor in the world market. We look forward to greater participation by our contractors in the future as we mutually strive to build quality and reliability into the products and services that are so vital to our space program and our country.

George A. Rodney
Associate Administrator for Safety,
Reliability, Maintainability and
Quality Assurance

Our Business is Support Services

Photos: (clockwise from above) Crew escape pole is being tested by the Air Force in a jump over the California desert; Wellness Center; Program Manager Moe Miller recognizes the winning Lockheed tennis team which placed first in a local tournament; launch and entry suit; Houston Lunar Lab.

Lockheed
Engineering & Sciences Company

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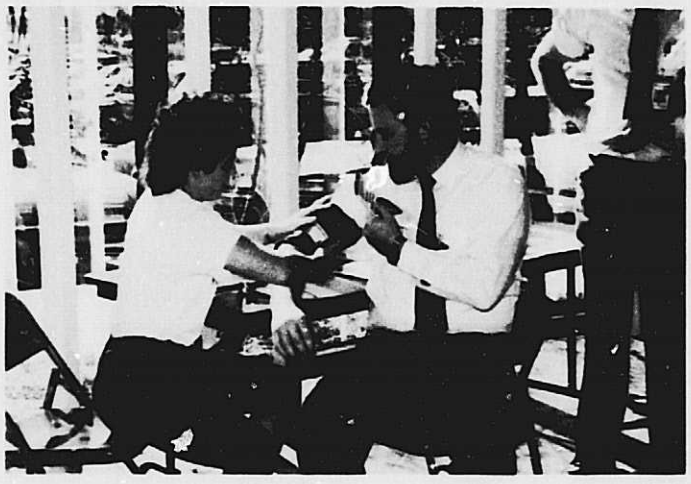
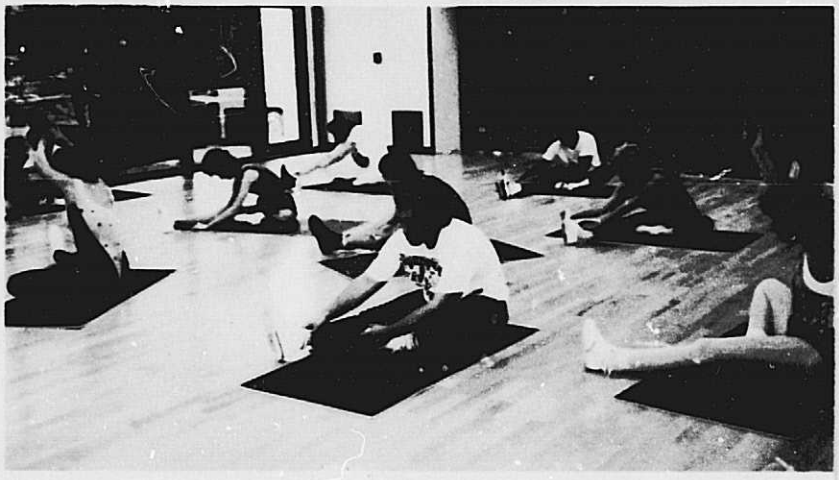


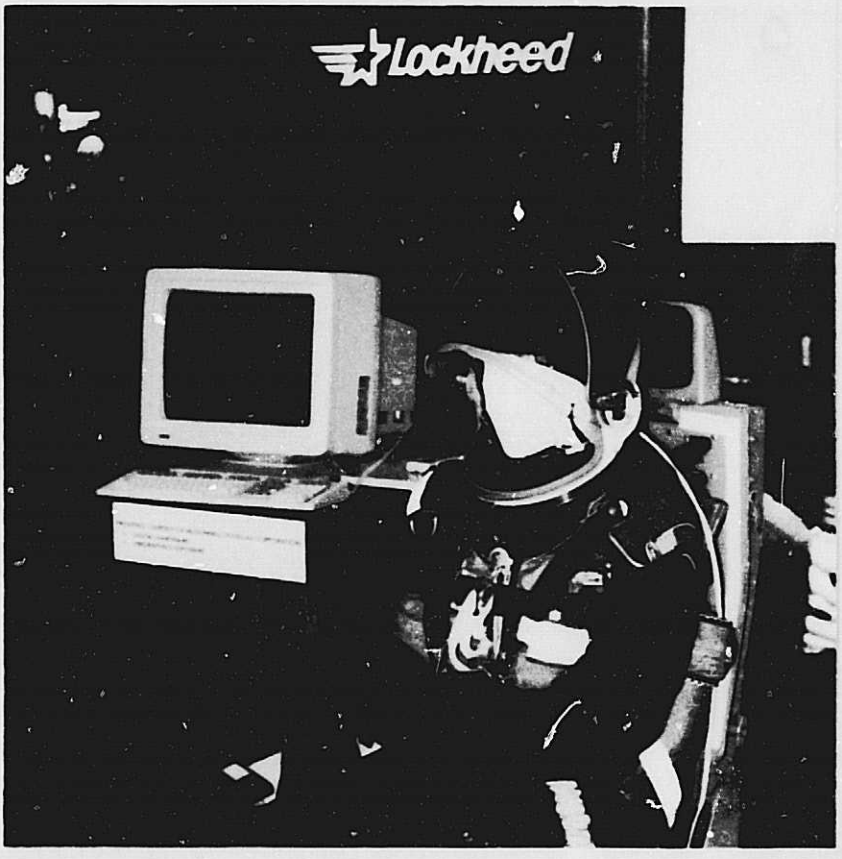


Quality, it has been said, is something that is difficult to put your finger on. The same could be said about the products of the Lockheed Engineering & Sciences Company (LESC). The company exists to provide management and technical services for its parent, Lockheed Corporation. LESC is unique among Lockheed companies in that it does not sell hardware. Its only product is providing high-technology engineering, science, management, and technical support for government programs.

The Engineering and Sciences Program (ESPO) is one of several LESC programs. With more than 2,100 full-time employees, ESPO is the principal research and engineering contractor at the National Aeronautics and Space Administration-Johnson Space Center (NASA-JSC). For more than 25 years, ESPO has supported all major manned spaceflight programs: Gemini, Apollo, Skylab, Apollo-Soyuz, Space Shuttle, and Space Station Freedom.

The quality work of LESC ESPO received special recognition in 1989 when it was named the recipient of the 1989 NASA Excellence Award for Quality and Productivity. The award—which is designed to recognize the highest standards of performance among NASA's aerospace industry contractors, subcontractors, and suppliers—is the highest honor bestowed upon LESC ESPO. The award process involves completing an extensive application and on-site visits by examiners to validate claims made in the application. LESC is the only recipient to receive the award for 1989 from a field of eight finalists, and is the first support service contractor to win the award.

The following pages contain an overview of LESC ESPO's services and a detailed examination of its focus on the customer and the organization. These techniques have been developed by an organization that specializes in service, but can be adapted and applied by any organization that wishes to pursue total quality.



ESPO Provides Engineering Services to NASA-JSC

ESPO has established itself as a leading technical service contractor through its past and ongoing engineering developments for the Space Shuttle. Technical areas include automation and robotics; the thermal control subsystem; integrated guidance, navigation, and attitude control; tracking and communications; spacecraft propulsion systems; crew and thermal systems; lunar specimen curation laboratories; data management; and habitability, human factors, and food subsystems. Much of the current engineering activity supports planning and design of the space station test beds, with particular concentration in the areas of data management, thermal management, and tracking and communications. The strong fundamental bases of computer science, systems engineering, and simulation provide enhanced capabilities to NASA in all areas of engineering. ESPO's long-standing strengths of avionics, communication and tracking, and proximity operations tools and skills are being applied to future space project needs.

"ESPO is an information-based organization that is, in the words of noted management expert and author Peter Drucker, "composed largely of specialists who direct and discipline their own performance through organized feedback from colleagues, customers, and headquarters."

ESPO provides major support to NASA-JSC in its responsibilities for the design, development, operation, and overall mission management of both JSC-assigned, NASA-sponsored payloads and commercial payloads scheduled for flight on the Space Transportation System.

ESPO Provides Science Services to NASA-JSC

ESPO designed and developed part of the Shuttle Crew Escape System (SCES), a critical return-to-flight project. In addition, ESPO supports the shuttle astronaut crews in a wide range of Earth observation activities, providing crew training and mission support. ESPO plays a major role in coordinating crew activities with the Earth's sciences community needs. The photography taken by the astronaut crews, for example, is documented in mission catalogs and in an electronic data base, and is then made available to the Earth's sciences community. For more than six years, ESPO supported NASA-JSC in developing the large format camera and its associated attitude reference system. This camera constitutes the most advanced commercial mapping camera in existence, and the high-resolution photography is used in a variety of scientific disciplines. ESPO also provides scientific and technical support for solar system exploration programs at NASA-JSC. Lockheed scientists and engineers analyze extraterrestrial material samples, develop spaceflight instruments for evaluation of materials and man-made near-Earth orbital phenomena, and build prototype equipment for lunar base development and planetary exploration missions.

Because of the unique nature of support services contracting, with its highly diverse and specialized functions, it is a challenge to measure its quality and productivity. There frequently is no piece of machinery to be inspected or tested to confirm excellence of quality, no product to be sold in the market place and become subject to mass customer feedback or consumer reports, and no conveyor belt with products rolling off to be counted and measured against man-hours. In short, there is nothing tangible remaining that appears measurable. Indeed, as soon as a service has been performed, it is by definition a thing of the past.

Yet most of us can recall instances when we have received either very good service or very poor service—and we know there is a very real difference. For the support service contractor who is committed to excellence, the challenge consists of first defining and measuring that difference and then meeting the standard of excellence that has been defined.

Over the years this pursuit of excellence has led us at LESC ESPO to examine all facets of traditional quality assurance and productivity methods. As a result, we have developed powerful operating methodology to sustain the highest standards of quality and productivity in an engineering and science support service environment. We have formulated, tested, adapted, and maintained a system to ensure that NASA, the customer, is completely satisfied. "Customer satisfaction—that's what we're about on a day-to-day basis," said Moe Miller, LESC vice president and ESPO manager.

At the very core of the operational system is an organizational structure designed for responsiveness and effectiveness in the management of 70+ decentralized job orders. Each of these job orders is a minicontract in which resources and deliverables are directly negotiated between the NASA-JSC monitor and the Lockheed personnel performing the work. Project requirements vary widely. The matrix project management structure allows the flexibility necessary to respond to this variety of requirements.

Also central to task performance is a Technical Information Processing system (TIPS) that is uniquely tailored to support team projects. This enhancement to team effort is important both within the company and between ESPO and NASA. A vitalization process that ensures a proper skill mix with realistic costs is operative within the company to give added benefits to NASA. An environment of open communication and

employee participation, together with a leadership development program that enables and empowers superior performance, provides a key stimulus to continuing excellence in both quality and productivity. The effectiveness of these innovations and ESPO's continuous improvement are demonstrated by sustained ratings of excellent for cost, schedule, and technical performance in the award fee evaluation process since 1978 and also by the following accomplishments:

- Selection as the recipient of the 1989 Johnson Space Center Team Excellence Award. This marked the second consecutive year that ESPO received this honor.
- Vital role in critical return-to-flight activities. In the wake of the Challenger accident, ESPO developed the Shuttle Crew Escape System and implemented the "clamshell fix" of the nitrogen tetroxide leak prior to the Space Transportation System 26 (STS-26) mission.
- Selection for NASA-JSC's Engineering Support Contract (ESC). This contract, awarded in 1987, is the second largest contract supporting NASA-JSC.
- Early completion of ESC phase-in activities. The transition was completed 90 days ahead of schedule, saving the government $5.2 million.
- Additional ESC staffing growth of 88 percent since the contract was awarded. While this growth took place, award fee evaluations remained excellent.
- Verifiable cost reductions of $55.4 million since 1984. Each year has shown a steady increase in both the number of submittals and dollars saved.
- Continuing implementation of the Technical Information Processing System (TIPS), a network computer system to increase productivity and quality. Phase II was implemented in 1988 with the installation of 186 workstations and associated software; workstations and a terminal, printer, and plotter to support technical computer-aided design and computer-aided engineering; and a microwave link to connect workers in the new Lockheed Plaza 4 with existing networks.
- Continual pursuit of technical excellence. About 27 percent of employees completed one or more of the 26 in-house technical training courses offered in 1988; 10 percent participated in the tuition reimbursement program; and 45 percent attended one or more of the 20 wellness center programs. Since 1984, 348 employees (including two-thirds of all managerial employees) have completed the Distinctions of Leadership course.
- Emphasis on employee involvement and recognition. About 40 percent of employees participated on one or more of the 48 employee teams in 1988; award programs recognized 37 percent of employees for group achievement and 39 percent for individual achievement.

At ESPO we continually strive to improve the quality and productivity of operations as a support service contractor. Commitment to teamwork and customer satisfaction is a way of life.

Focus on the Customer

All ESPO Employees Understand Performance Requirements

ESPO's understanding of performance requirements is a natural result of a close working relationship with customers. The partnership with NASA-JSC, which allows the joint identification and solution of problems, is greatly facilitated by our organizational structure, which closely mirrors that of the NASA-JSC divisions that ESPO supports. Every one of these NASA divisions has its counterpart in an ESPO department, each of which is overseen by an operations manager. These operations managers, who are the primary contacts with the NASA-JSC divisions, work with a great deal of autonomy. This is a necessity because each operations area conducts work on a number of individual job orders.

Each job order manager oversees a semiautonomous work group that meets weekly, or often daily, with the NASA-JSC monitor. These meetings take place at JSC or in the ESPO facilities and include NASA, ESPO, and subcontractor employees from all levels. NASA visits ESPO regularly, and an open door policy is maintained to promote close working relationships.

Requirements are clearly documented in the job order and in supporting clarification work authorizations, such as task agreements and action documents. These are understood throughout the organization. Advice or clarification can be obtained easily when the need arises because ESPO's entire work force is no more than five minutes away from NASA-JSC.

In addition to such ongoing communication, we receive feedback through the quarterly evaluation of each job order. We have more than 700 job orders. Each one is graded quarterly on technical work performance, supervision and management, and response and schedules. At the program level, we receive feedback from the technical manager and contract officer on cost and program management performance for the entire contract. This timely feedback from the customer allows the process to be refined and excellence to be sustained.

NASA recognizes ESPO's work

Proof of ESPO's outstanding performance came in March 1987 when we were granted the Engineering Support Contract, the second largest contract supporting NASA-JSC. The contract covers an initial two-year period with three two-year options. The ESC consolidates the work previously done by three companies—ESPO, McDonnell Douglas Astronautics Company, and Northrop Services, Inc.—under three separate contracts. Thirty percent of the ESC represented new work for ESPO, including support for the NASA-JSC Crew and Thermal Systems Division, Propulsion and Power Division, and Lunar Curation Laboratories.

Phase-in activities began immediately after the award announcement. To handle the increased work load, we hired 95 percent of the incumbent work force from Northrop and 75 percent from McDonnell Douglas. By May 10, 1987, (well ahead of the targeted month of August 1987) we brought these 336 new people on board. The quick work saved the government $5.3 million. Moreover, to ensure a smooth transition, we had completed 50 memoranda of understanding (MOUs) with the incumbents.

In the initial evaluation of the contract for the period ending July 1987, the NASA-JSC technical manager made special note of ESPO's outstanding performance during the intense period of transition to the new ESC contract. The company's performance was rated "high excellent." This work included the identification, recruiting, and hiring of the incumbent work force; the development and implementation of three-party MOUs; and the initiation of ESC work authorization documents (job orders). Excellent progress in TIPS implementation and a continued high level of performance during the high activity transition period were also noted. Additionally, since the start of ESC, ESPO has received more than 400 letters of commendation for excellent performance from NASA.

Working with customers

Areas of minor deficiencies will undoubtedly arise in any organization performing the diverse and complex tasks necessary for manned space exploration. The quarterly evaluation of each job order pinpoints potential problem areas. When the potential for a deficiency is identified, the operations manager of the department to which the job order is assigned immediately discusses the situation with the ESPO job order manager and the NASA technical monitor. (An operations manager is responsible for a department and is also the primary ESPO interface for support to a counterpart NASA division.) If additional resources or capabilities are needed to correct the deficiency, the operations manager has immediate access to the resources of both LESC and the entire Lockheed Corporation. Sustained "excellent" grades, however, are proof that areas of deficiency in ESPO are of minimal significance. The contract defines "excellent" as follows: "Performance is outstanding in essentially all respects, approaching the best that could be expected of any qualified contractor. Contractor has greatly exceeded the standard of performance which would be expected of a qualified contractor. Areas of deficiency are very few and, overall, are considered relatively unimportant. Contractor shows initiative in executing the job and achieving improvements."

ESPO demonstrates a high degree of initiative

The working relationship set up between NASA and its support service contractors calls for NASA-JSC to identify tasks and delegate them to the contractor. However, because ESPO has earned the trust and respect of NASA through sustained excellent performance, ESPO frequently takes the initiative to identify critical tasks and improvements to facilitate and enhance the joint mission of manned space exploration. This process is part of a proactive approach that calls for a constant examination of work to seek and find opportunities for improvement.

In the early 1980s, for example, ESPO recognized that automation of its processes through the use of desktop computers could greatly enhance quality and productivity. Studies on the use of computers in the workplace resulted in the development of TIPS, an operating network of computers, engineering workstations, personal computers, and associated software specifically designed to increase the productivity of the work force. TIPS is visible evidence of a commitment to productivity. By implementing such ideas as automation in the workplace, everyday work is performed more efficiently.

Sometimes, special situations arise that offer the opportunity to devise creative solutions. Such was the case in two separate tasks in the critical return-to-flight period. During the Main Propulsion System (MPS) Failure Modes and Effects Analysis (FMEA)/Critical Items List (CIL) review for the STS return to flight, the Lockheed team proposed the use of laptop computers and projection devices to facilitate the review sessions. ESPO recommended loading the pertinent data for each FMEA into a word processor and then displaying the output from the computer onto an overhead display. Participants could thus review the pertinent data and make appropriate changes together. Not only was the entire FMEA review process significantly accelerated, but the quality of the new completed product could not have been obtained through the former

process. The NASA-JSC customer commented that the new devices and computers paid for themselves during the first two-week review meeting. They were employed for seven additional review meetings.

While the STS-26 vehicle was being checked out for the return to flight, a nitrogen tetroxide leak was discovered in an inaccessible portion of the Orbital Maneuvering System (OMS) pod. A joint ESPO and NASA team designed, fabricated, and demonstrated a clamshell device that could seal the leak. This breakthrough allowed the shuttle to be launched without the significant delay for rollback and de-mating. The ESPO engineer responsible for this ingenious device was recognized and rewarded by both NASA and ESPO.

In taking the initiative to recognize and provide for future needs, ESPO established the Artificial Intelligence Project Office (AIPO) in 1984 to research needs and develop capability in the newly emerging artificial intelligence (AI) field. The result was the creation of an AI laboratory facility staffed with trained personnel. NASA has recognized this capability, and ESPO has delivered five major expert systems to NASA-JSC. These systems assist in such diverse areas as hardware diagnosis and complex space station task planning.

Planning to ensure customer satisfaction

The tasks on the ESC contract are communicated by NASA-JSC technical monitors via 700 or more individual job orders. The majority of these job orders are stand-alone tasks—independent of other ESPO job orders—that are part of a larger project managed by ESPO. This is typical of support services contracting. We provide schedules for each job order, and the job order manager is responsible for meeting schedule requirements.

Guidelines for project plan development are included in the Project Management Handbook. This handbook is augmented with formal project management training courses. Topics covered include schedules, deliverables, resource estimates, and planning and control tools. Overall customer satisfaction is graded quarterly on technical work performance, supervision and management, and response and schedules. NASA provides an overall summary of grades at the ESPO operations level and again at the contract level.

Adapting to changing conditions

Variation is a fact of life. ESPO realizes that and all employees have demonstrated exceptional responsiveness to rescheduling and reprioritizing projects when the need arises.

One of the most complicated and demanding projects was the Westar-Palapa satellite retrieval mission. To meet the critical time lines of this project, ESPO rescheduled and reprioritized its many ongoing activities to free the necessary resources for support to the retrieval. The project involved about 10 percent of the total work force over a short period of time, and required the coordination of many subcontractors. This effort, completed in only nine months, involved several NASA centers and contractors in identifying the issues, including the requirements for hardware, software, procedures, crew training, certification, installation, and flight and post-flight activities. It was a high-intensity, high-profile effort and one with a high payoff to NASA's can-do image. ESPO team members were among those recognized with a NASA-JSC group achievement award for their part in this historic achievement. The tiger-team skills developed on this project have been applied to many subsequent projects.

NASA knows it can rely on ESPO's responsiveness when the unexpected occurs. For both the Westar-Palapa and Leasat satellite retrieval missions, ESPO resources were quickly redirected to get the high-profile job done quickly and correctly.

When the need arose for the in-space retrieval and repair of the Leasat satellite, the experienced ESPO team from the Westar-Palapa satellite retrieval mission was quickly reorganized. The subsequent effort resulted in a successful in-orbit repair of the satellite, establishing the important capability for satellite repair in space. This capability has long been recognized as a key to success in marketing NASA's satellite program for worldwide commercial use.

After the STS 51-L accident, ESPO again drew upon its long-standing skills in project management and teamwork to analyze the accident. ESPO management assembled a 25-person team of image and photographic interpreters in a one-week period and acquired all the necessary hardware and software to begin data analysis. Some 1.775 million frames of still photography and 110 rolls of videotape were examined, aiding in the timely analysis of the disaster. ESPO participants received an award from NASA-JSC for their role in this investigation.

In addition to quick and successful handling of these incidents, ESPO has also demonstrated exceptional responsiveness to NASA's return-to-flight requirements. After the STS 51-L accident, a decision was made to provide the orbiter with a crew escape capability. A team of ESPO personnel and their NASA counterparts explored several concepts of crew escape systems. The Pole Crew Escape System (PCES) was recommended and, along with the addition of the newly designed launch and entry suit (LES), comprised the total SCES that was developed and certified for orbiter use. The PCES and LES enable all crew members to safely escape from a disabled orbiter during controlled stable subsonic flight. The deployed PCES permits crew members wearing the LES to slide down the pole and clear the orbiter.

The LES project team was faced with three immediate problems: the shortness of the schedule, several large procurements, and a procurement organization not staffed for this type of activity. The organization of a flight procurement section, therefore, was the first step in meeting these challenges. The reorganization included separating purchasing, subcontract administration, and procurement operations. The Lockheed corporate resources were also utilized to meet special procurement problems. To further alleviate time and money constraints, ESPO and NASA made the decision not to subcontract the suit fabrication and integration task and to perform the final assembly in-house.

Because a short project schedule typically presents problems, project personnel met frequently to review and update schedules and Gantt charts. In this case, Artemis, the SCES scheduling tool, displayed not only engineering functions but also procurement activities. The project schedule became the focal point of discussions at weekly activity meetings held between the project engineer, the procurement supervisor, and the purchasing agent. During the most critical period, March through July 1988, meetings were held daily to coordinate and minimize negative redundant activities. Where unique problems so dictated, Lockheed corporate staff were used to make personal contact with the vendor and work out problems.

The ESPO project engineer gave the customer daily progress reports on the engineering and procurement action items. Problem areas were quickly and clearly identified through the use of colors on the schedule chart. The straight-facts approach and clear project tracking aids helped to direct customer-contractor actions quickly and efficiently.

Because it was a return-to-flight activity, SCES had the potential to become a major stumbling block to meeting the STS-26 launch schedule. Therefore, the ESPO program manager and department management personnel were knowledgeable of the SCES activities and acted accordingly. All procurement meetings adopted and publicized an open door policy to ESPO and NASA management.

The SCES project was very successful because it effectively used the matrix management approach to staffing projects and ESPO's proven ability to add staff quickly. ESPO organizational tools such as Artemis and other scheduling tools, as well as the management information system (IPMIS), proved capable of providing early indications of potential problems. The effective use of a project schedule enabled team members to identify and address areas of concern. Timely response, coordination, and effective use of project tools by team members prevented problems that might have harmed other tasks.

In the end, the ESPO SCES team delivered the suits on time and within budget. NASA indicated their appreciation to ESPO by sending personal letters to nearly 100 team members thanking them for "dedicated support and hard work." Additionally, the ESPO program manager received two separate letters, one from the chief of the Man-Systems Division and the other from the Launch and Reentry Suit project manager. Both cited the exceptional organizational and individual efforts made by the procurement department personnel.

ESPO also has supported the JSC Engineering and Science Divisions in the study of potential crew emergency return vehicle (CERV) subsystems and acquisition of the necessary technology for their implementation. The CERV Project Office requested ESPO management to conduct a rapid response study that focused the subsystem technology efforts in a working vehicle configuration. Within one week the job order was executed, the team was formed, and a working "war room" was established. A recommended configuration was developed and presented to NASA-JSC management, and a presentation by NASA-JSC was made to the NASA associate administrator.

Keeping costs under control

Cost is controlled at the individual task level and summed up to the total contract level for both costs and funding. NASA-JSC authorizes the labor hours and material expenditures; ESPO controls the labor hour rate. Total contract costs are controlled to individual cost elements such as labor, travel, relocation, and overhead. Elements of cost are incorporated into the self-evaluation plan as total average labor rate, overhead rate, etc. Every six months, we prepare a self-evaluation of actual versus planned performance and review it with NASA.

The ESPO cost reporting system provides a process whereby ESPO informs NASA-JSC of cost changes or concerns in a timely manner. At all levels of cost reporting, we conduct an analysis of cost to date, forecasted cost, and budget variances. This analysis is included in the cost report and provided to NASA-JSC shortly after the close of the applicable accounting month. Informally, cost data are reviewed in weekly status meetings with the NASA-JSC technical monitor and in monthly job order written reports. Long-range cost concerns are documented as memoranda and promptly transmitted to NASA-JSC.

Significant savings

The cost-reduction program is operated by a committee that includes representatives from each operations department. The committee establishes annual goals for cost savings; thus far, each goal has been met or exceeded. Cost reduction

submittals are evaluated on the anticipated dollars saved from an action already implemented and are fully supported by verifiable facts. Employees are rewarded with savings bonds for verifiable submittals. ESPO encourages employees to develop innovative ideas that will increase the operational productivity of government programs in a more cost-effective manner.

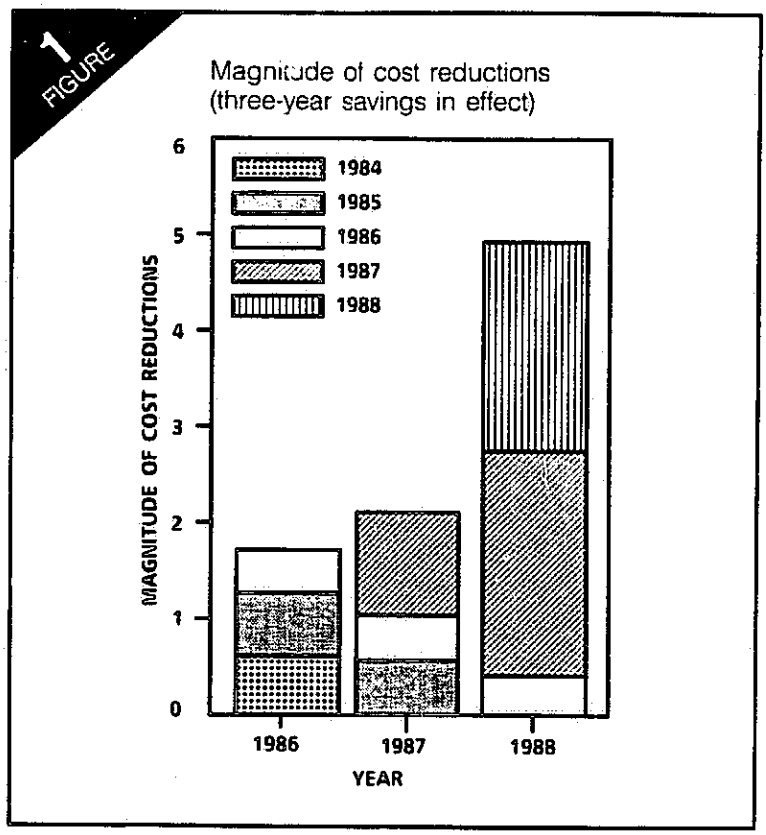
An analysis of approved cost reductions revealed that most cost reductions remain in effect for at least three years; some are effective much longer. The first-year savings are usually less than those in later years because of implementation costs. Note that 1987 is the first year that we considered costs of implementation, so savings from 1984 through 1986 are carried through as is. Figure 1 illustrates the magnitude of the cost reductions in effect for 1986 through 1988.

Keep the customer informed

ESPO has an excellent record of communicating with its customers. Because relationships between ESPO employees and customers exist at many levels, responses to inquiries tend to be immediate and informal. Even though we recognize the advantage of the quality communication that is a natural by-product of this close working relationship with NASA, we realize that good communication does not just happen. Therefore, ESPO does all it can to keep the customer informed and to maintain an environment of openness and objectivity. We use regular meetings, special meetings and presentations, and written communications to stay in touch. Each job order manager, for example, oversees a work group that communicates weekly, or often daily, with the NASA-JSC monitor. In addition, operations managers conduct meetings with the NASA technical manager's representatives and the NASA division chiefs or branch chiefs on a regular basis, frequently at weekly intervals. Regular weekly and monthly job order reports with clear, factual information in concise form are submitted to the customer. In addition, a quarterly progress reports cover all significant work performed for NASA-JSC during the previous three months.

The openness and objectivity of our communications are illustrated by the types of presentations and training we offer to our customers to provide a clear understanding of the mechanisms of our business management systems. A business system presentation titled "Solving the Project Control Puzzle" was given to ESC technical managers in 1988. In addition, an eight-week session on NAS 9-17900 Job Order/Project Control was offered to NASA management in January 1989. More than 30 NASA employees participated. These types of interactions foster an openness and objectivity that can be obtained only when all parties are fully informed.

FIGURE 1



Through the use of detailed written procedures, we ensure that technical documents delivered to our NASA-JSC customers are accurate and timely. For each deliverable document, a schedule is prepared and submitted to the cognizant operations manager. Each document is reviewed for technical content by an independent reviewer before delivery.

Clear, concise, and factual information is frequently exchanged with NASA-JSC as we conduct several levels of technical reviews during the development of projects. These include design (conceptual, preliminary, and critical), acceptance, and periodic status reviews. The NASA-JSC review item disposition (RID) form, in conjunction with action items, is the mechanism used to identify a deficiency. Cost and schedule reviews are usually conducted between the NASA-JSC technical monitor and the ESPO job order manager; however, this type of information is often included in technical status reviews also. Cost and schedule reviews using shared products (common reports distributed to both ESPO and NASA-JSC) provide managers of both organizations the opportunity to view the project in terms of real cost and funding, enabling management to agree on the remaining action items.

Quality assurance of support services

Our Quality Assurance Plan for Engineering and Scientific Support Services, which is approved by the NASA-JSC technical manager for the ESC, describes quality requirements and responsibilities for our contract. The quality assurance (QA)

requirement for each task is determined and specified in the job order by the approving authority at JSC. The following is the interpretation of the job order categories:

Category I: job orders for flight hardware development, repairs, or modifications. The baseline requirements for safety, reliability, and quality assurance (SR&QA) are specified in NHB 5300.4 (1D-2) or JSC-30000, part 9 (if space station). Three documents—the LEMSCO Safety Plan, Reliability Plan, and Quality Plan—will be used as tailored by the program requirements document (PRD), the specification and assembly drawing (S/AD), or the end item specification (EIS).

Category II: job orders for payloads and experiments developed under contract NAS 9-17900. The LEMSCO Safety Plan, Reliability Plan, and Quality Plan will be used as tailored by the experiment plan, the S/AD, or the EIS.

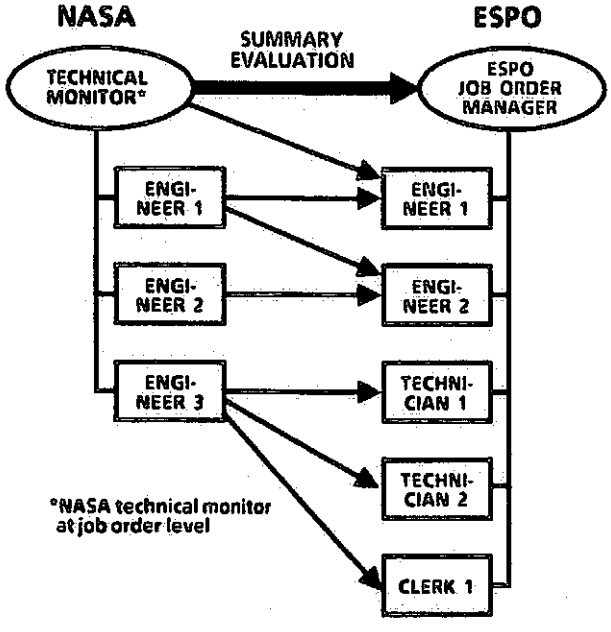
Category III: job orders for non-flight equipment. These do not require formal QA procedures. Good workmanship per the LESC Workmanship Inspection Manual and adequate informal documentation to commercial standards are acceptable.

Category IV: non-hardware development job orders. A professional end item product is required.

An analysis of all job orders shows that less than 15 percent of our work falls under categories I and II, which have rigid quality assurances procedures that are clearly defined and documented. The other 85 percent of our work falls under categories III and IV, in which quality assurance activities are dictated by the nature of the project.

FIGURE 2

Almost every customer interface yields an evaluation of our work



NASA QA personnel perform all on-site inspection functions at the NASA-JSC facility, even for ESPO-fabricated hardware transferred to NASA-JSC for interim or final testing. Therefore, NASA QA personnel, with assistance from the ESPO engineers and technicians located on-site at NASA-JSC, perform the necessary tasks associated with defect prevention on-site. ESPO QA has the responsibility to perform these functions for the hardware only when it is located in the ESPO (off-site) facilities.

Because we are responsible for off-site QA activities for hardware that will eventually be moved on-site, we have developed our QA system to mirror the NASA-JSC QA system. This approach ensures continuity in tracking and prevents the occurrence of problems, discrepancies, or other unsatisfactory conditions as we support NASA-JSC in the development, design, purchase, fabrication, testing, qualification, and repair of hardware. ESPO's cooperative interaction with NASA-JSC is illustrated by the recent addition of the launch and entry suit to the space shuttle program. ESPO provided the procurement to NASA specifications, coordinated the quality requirements with the vendor, and provided the quality receiving inspection functions. The suit components were assembled and tested at NASA-JSC with NASA QA surveillance and tested by the Army and Navy with NASA/ESPO quality designees. The flight data package was prepared by ESPO, using common forms and procedures. The suits were shipped to John F. Kennedy Space Center and there were no unresolved discrepancies.

If a problem or discrepancy is noted during the performance of any hardware-related task, a discrepancy report (DR) is written. A DR requires a written disposition approved by both NASA and ESPO engineers. The DR provides a historical record as well as information to be used in trend analysis. This Problem Reporting and Corrective Action (PRACA) system, which is common to NASA-JSC and ESPO, ensures the smooth flow of problem and discrepancy reporting as government furnished equipment (GFE) hardware moves between the Lockheed off-site facilities and the NASA-JSC on-site laboratories.

In addition to a formal problem-reporting system, we have developed a combined NASA-ESPO peer review and internal approval hierarchy which ensures that only quality products, analysis results, reports, and services are delivered. Each ESC deliverable document receives an independent review for technical content and conformance to requirements. The breadth of task coverage and peer review is evident in the 700 job orders because virtually every NASA-JSC engineer in the directorates we support critiques the quality of ESPO products. This interaction is represented in Figure 2.

The nature of research and engineering (R&E) support requires services and flight hardware

that are free of defects and discrepancies at the time of delivery and acceptance. Products and services are either unique or are built for two or three units at most. Accordingly, component quality is evaluated at each stage of a process from background research through design and modeling to the final formal delivery. For GFE hardware products, an acceptance data package is maintained for each component or unit. For non-hardware services, a system of peer reviews is used to ensure completeness and accuracy of reports and analyses. Our consistently high performance grades demonstrate that our services are error-free.

Typical services provided by the ESPO SR&QA Office include the preparation of FMEA/CILs, safety analysis reports, hazard analysis reports, and proactive participation in informal and formal design reviews, test readiness reviews, acceptance reviews, first article configuration inspections, and failure analyses.

In our business of providing support services to NASA-JSC, measuring technical performance at a microlevel is difficult because requirements change frequently. Trending against standards implies fixed, stable requirements. Often the first task on our job orders is to define or refine the requirements for a system or project. When requirements are undefined or are changing, the application of preset standards becomes counterproductive. Because nearly all of the spaceflight equipment items developed or processed by ESPO are produced in very small quantities, there is no significant statistical basis for trend analysis.

However, ESPO's in-house processes of administration, procurement, fabrication, and inspection are amenable to trend analysis. An example of the success experienced through performance of this trending is reflected in the chart illustrating off-site (ESPO) Material Review Board (MRB) formal actions per DR (see Figure 3).

As reflected in the trend chart, the percentage of in-house discrepancies requiring MRB formal action has significantly decreased since 1986. The downward trend in MRB actions is of particular importance because it signifies not only significant dollar savings but also increased reliability of hardware. We perform trending on nonconformances per total material dollars on flight hardware job orders, as shown in Figure 4.

To provide a representative sampling of QA activities for the highly diverse tasks we perform on the ESC, we have selected sample areas for discussion: software quality assurance, flight hardware and related services (as exhibited on the SCES project), Crew and Thermal Systems Laboratories (CTSL), and the Lunar Curation Laboratory.

- **Software quality assurance.** ESPO's software development process follows the classic software development life cycle: system engineering and analysis, software requirements analysis, design, coding, testing, and maintenance. This process is documented in our Software Engineering Standards and Practices Guide. ESPO also participates with Lockheed Corporation in establishing the overall set of standards, procedures, and checklists for software development. Much of our software is developed in support of engineering and scientific studies, including simulation and modeling of systems that have dynamic properties and frequently changing requirements. This type of software development is accomplished by creating a prototype of the program that must be built. The prototype serves as a mechanism for defining requirements. The final version of the software is engineered for quality and maintainability.

  Software quality assurance, which is applied at each step in the software engineering process, begins with a set of technical methods and tools to achieve high quality in both specification and design. Formal reviews are conducted by the technical staff for the sole purpose of identifying quality-related problems. Software development activities are monitored to ensure compliance with established standards and procedures and to minimize rework during the analysis, design, coding, and testing phases. Software testing includes a series of test cases to ensure effective error detection. Change control is applied during software development and during the software maintenance phase to minimize the impact of software modifications. Reporting mechanisms and procedures establish a history of the software development activities that aid in diagnosing and correcting latent errors during the maintenance phase.

  Project and task management personnel regularly review the progress of software development projects. The ESPO office responsible for the project software development conducts reviews and audits in compliance with an approved software development plan. This plan includes, as a minimum, a software requirements review and a system design review addressing the entire system, a preliminary design review, a critical design review, and a functional and physical configuration audit on each computer program configuration item (CPCI) being developed.

  Discrepancy detection, analysis, and correction are controlled through procedures internal to and managed by the developing organization prior to CPCI testing. As soon as CPCI testing begins, software discrepancies are subject to a closed loop corrective action process. Full formal discrepancy reporting and corrective action procedures are in effect throughout and after the formal testing activity.

  We have developed software applications to monitor trends to improve the performance of systems. One example of the use of trend data in a software activity is the use of a QA

processor, developed by the Advanced Programs Department, to find erroneous data points in shuttle aerodynamic data bases that Marshall Space Flight Center delivers to NASA-JSC in support of the liquid rocket booster (LRB) phase A design project. The data bases consist of tens of thousands of data values and are used for ascent trajectory performance assessments of candidate LRB configurations. The processor locates spikes in the data bases; when it encounters erroneous data points, it prints out the incorrect values and creates a plot of the affected aerodynamic data table. The processor successfully automates a QA function that would otherwise be an extremely tedious and costly manual process.

• **The Pole Crew Escape System (PCES).** The PCES, or pole component of the SCES, was designed to be used (in conjunction with the launch and entry suit) to enable all crew members to safely escape from a disabled orbiter. Because the flight hardware had to be functional in a life-threatening situation, the level and type of QA requirements and verification for this project were very stringent. Our intimate knowledge of the well-defined, yet complex, NASA SR&QA system allowed us to respond quickly and to complete and deliver a quality product on schedule. Working as an extension of NASA-JSC, the ESPO project team was required to meet rigorous NASA design criteria and quality control standards. ESPO's SR&QA Department was a first-level check in meeting NASA-JSC SR&QA standards. Final checking and approval were governed by NASA and NASA's QA support contractor. The ESPO SR&QA office also provided support to the NASA project manager in the preparation and review of project certification documents.

The project milestone review process is the system used to monitor and assess processes for all NASA hardware projects. As a typical hardware project, PCES was developed through this process. Applicable milestones were addressed in the data applicability matrix, a section of the program requirements document (PRD). The data applicability matrix provided a checklist to ensure all review milestones, documents, and reports were assigned and completed. The PCES PRD, prepared by a NASA/ESPO engineering team, was reviewed and approved by the NASA SR&QA office. Once the document was approved, the NASA Engineering Division was responsible for meeting all agreed-upon requirements.

The hardware design phase of a NASA project has two primary milestones—the preliminary design review (PDR) and the critical design review (CDR). The design review boards are staffed by engineering branches as well as SR&QA. Any concerns or discrepancies in the presented material are formally addressed on review item dispositions (RIDs). Each RID is subsequently catalogued and tracked to the point of its resolution. The status of each RID is presented to the design review board. All RIDs must be resolved shortly after PDR and CDR presentations. During PCES development, RID closeout actions were reviewed at weekly meetings.

To ensure that the provided services were error-free, the PCES hardware QA inspection included 100 percent verification of the PCES design requirements, which were identified on engineering drawings released in accordance with the NASA Engineering Drawing System. ESPO engineers followed NASA-JSC procedures for identifying critical dimensions and processes, and for release of the drawings. According to NASA procedure, once a drawing is released, it becomes a controlled drawing.

Engineering changes to controlled drawings are monitored and documented through the use of drawing change notices (DCNs), which share the same review and approval cycle as drawings. Once a DCN is approved, it becomes part of the released drawing. The manner in which drawings, DCNs, and documents are monitored ensures that the services and hardware produced will be of the specific configuration identified on the drawing. Using the inspection process, discrepancies were quickly identified and corrected, allowing the team to meet stringent schedule requirements.

• **CTSL—an engineering laboratory complex.** In the CTSL, we provide laboratory and facility support services for the operation of the thermal vacuum and altitude chambers. We operate and maintain the systems for vacuum pumping, solar simulation, cryogenics, manual operations, and instrumentation. One tool used to prevent problems and discrepancies is the test preparation sheet (TPS), which is written by qualified engineers and approved by their immediate supervisors. If a discrepancy should occur, a DR is written. The DR is reviewed and a disposition is made by qualified engineers. A signature loop has been established to provide optimum quality review of operating procedures used in maintaining facility readiness.

Mandatory inspection points (MIPs) are placed on TPSs by QA personnel to ensure that all aspects of design meet and conform to the intended purpose. The facility engineer monitors all work, verifying conformity and compliance to each required task.

Work control center personnel monitor and process all work orders, tracking the status and completion date of each order in the data system. Work is also tracked by means of the division schedule, which documents project start dates and completion dates for all work conducted within the services contract. Any problem that changes the status of a work order is resolved by the responsible project leader.

All documents associated with the test programs are tracked from start to finish on a computerized system. The documents include TPSs, DRs, test plans, FMEAs, and data

FIGURE 3

Downward trend in off-site MRB actions per design review over a two-year period

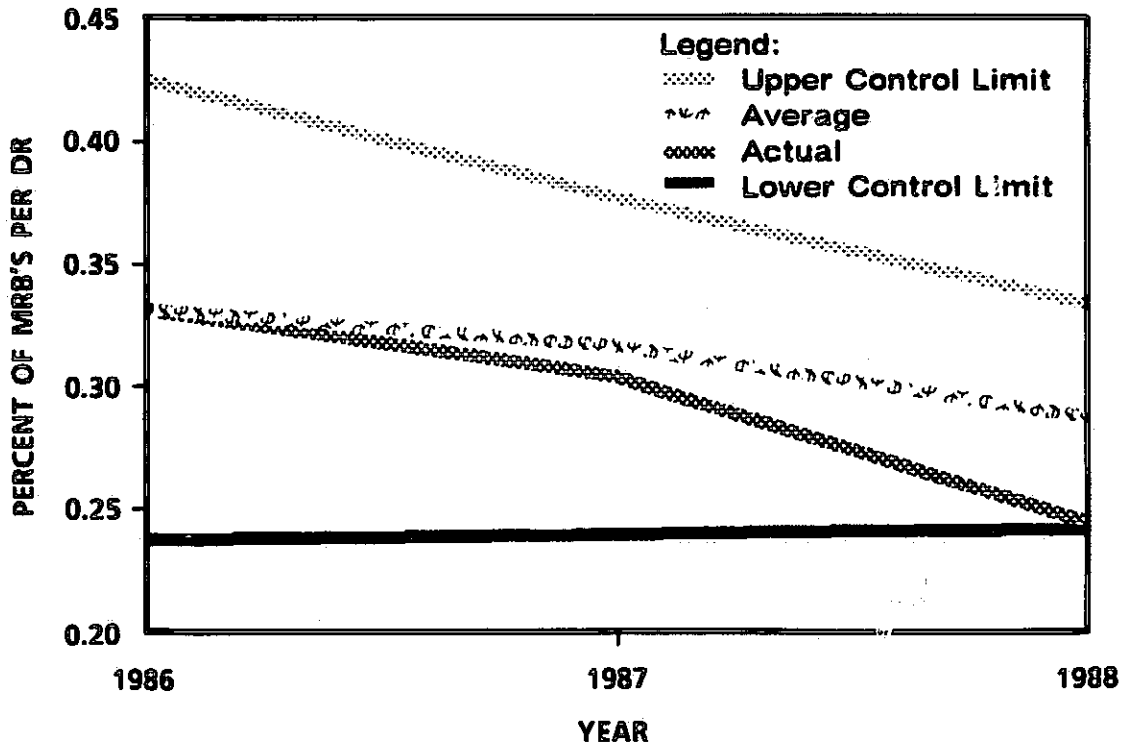
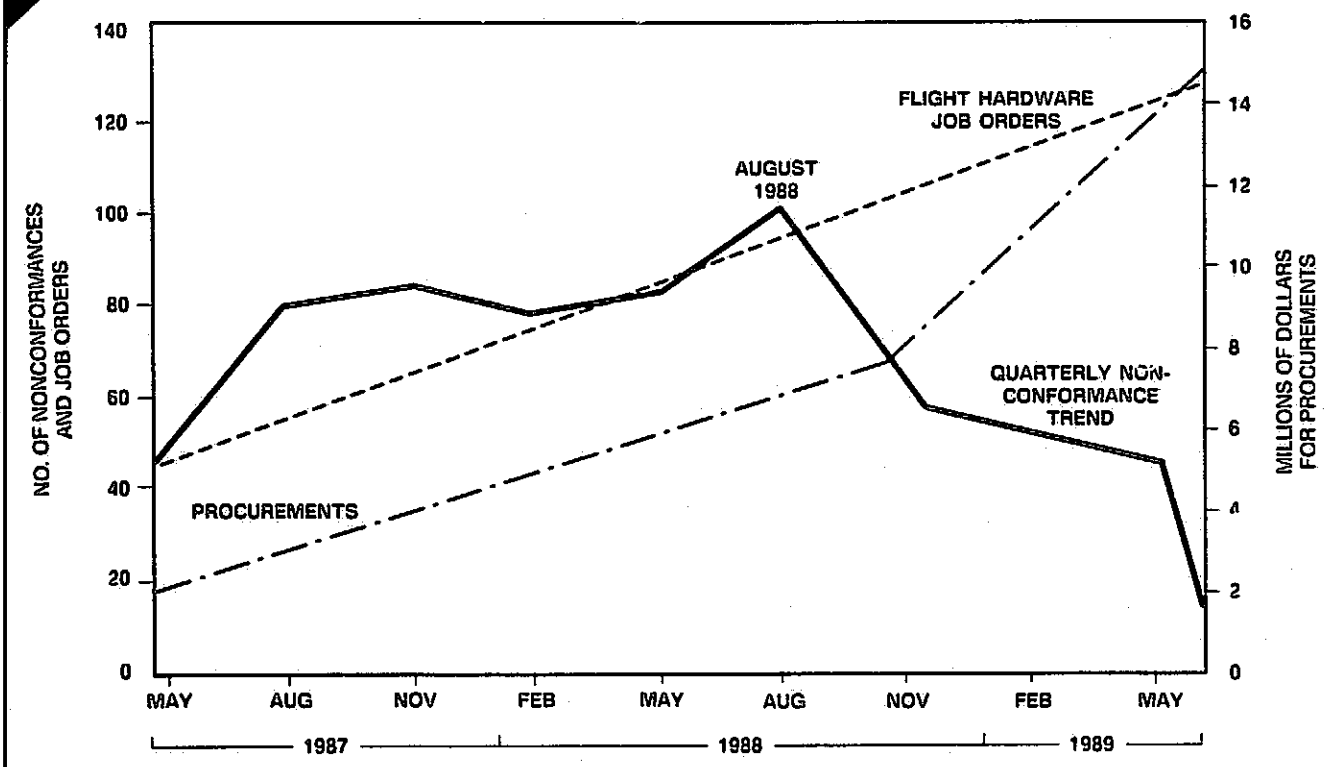


FIGURE 4

Our continuous improvement process shows dramatic reductions in nonconformances



requests. This system provides management visibility of the work processes to ensure that all problems are resolved quickly and that quality is built into each step of the testing services provided to NASA-JSC.

To provide services free of defects, discrepancies, and other unsatisfactory conditions, ESPO established a training plan for all critical personnel. The training plan is backed up by certification procedures to verify that only certified personnel operate critical duty station. Approximately 100 engineers and technicians oversee more than 200 critical duty stations. To optimize productivity, each person is certified on more than one duty stations. The certifications are reviewed on a regular basis, and also when a major modification occurs in a facility. The review process ensures that our team is certified and ready to perform quality services for NASA-JSC.

One CTSL procedure is the use of the System Test Branch Productivity Survey to improve the services provided to NASA-JSC. Both the test director and test requester are required to complete a survey form after each test. The completed surveys provide data on test objectives, test performance, schedules, resources, procedures, and facilities. All surveys are compiled and entered into the computer data base to rate performance and log trend tendencies. The data are used to upgrade procedures, operations, and facilities.

- **Lunar Curation Lab—a science laboratory.** Planetary materials—which include lunar samples, meteorites collected in Antarctica, and cosmic dust particles collected by high-flying aircraft—are curated in this lab at JSC with the support of ESPO. The term "curation" means protecting samples from contamination and loss, close accounting of changes in physical attributes of samples (such as containerization, storage location, weight, and scientific description), subdividing and preparing samples for distribution to principal investigators (PIs), and interacting with PIs and the public. Over the past 20 years, written procedures have been developed to maximize the sanctity of samples and minimize waste.

The physical state of the lunar sample collection is documented in verified data packs and computer data bases. The lunar data base is verified annually by inventory and daily by computer procedures. The number of discrepancies discovered by this process has been reduced to zero, while the number of individual, accountable pieces of lunar samples has grown to 65,000.

All sample-related activities are specified by curatorial orders (work action documents) that are tracked using a computer information system. This data base is updated and reviewed weekly. Target completion dates or notes pertaining to pending actions are monitored until the work is finished.

Computer error-checking, which contributed to the zero discrepancy rate shown in Figure 5, has evolved over the years. As patterns of errors were detected, actions were taken to prevent recurrence.

Using human resources efficiently

ESPO workers can reach their full potential through the matrix project management organization that has been implemented over the last seven years. This organization has made us very flexible, adaptive, and responsive to NASA-JSC needs. Level-of-effort support contracts have a tendency to constrain employees to a routine set of tasks. To combat this tendency, ESPO uses matrix management to provide expertise from one area for a problem in another. This is institutionalized at the ESPO operations manager level, which serves a particular NASA-JSC division, and is used on a tiger-team basis at the program level when NASA divisional lines are crossed.

In the last seven years, the sharing of expertise across organizational lines has increased the willingness of employees to take risks, be independent, identify with the company, and seek new opportunities within the company. From the company standpoint, the process has resulted in developing the next generation of managers and reducing costs by making employees familiar with multiple processes and areas of operation.

To maximize the cross-utilization of hourly employees in the matrix structure, we combined two union bargaining units in 1987. The new union agreement is uniquely tailored to the support services business, with work rules that allow cross utilization of skills both within the union and with professionals.

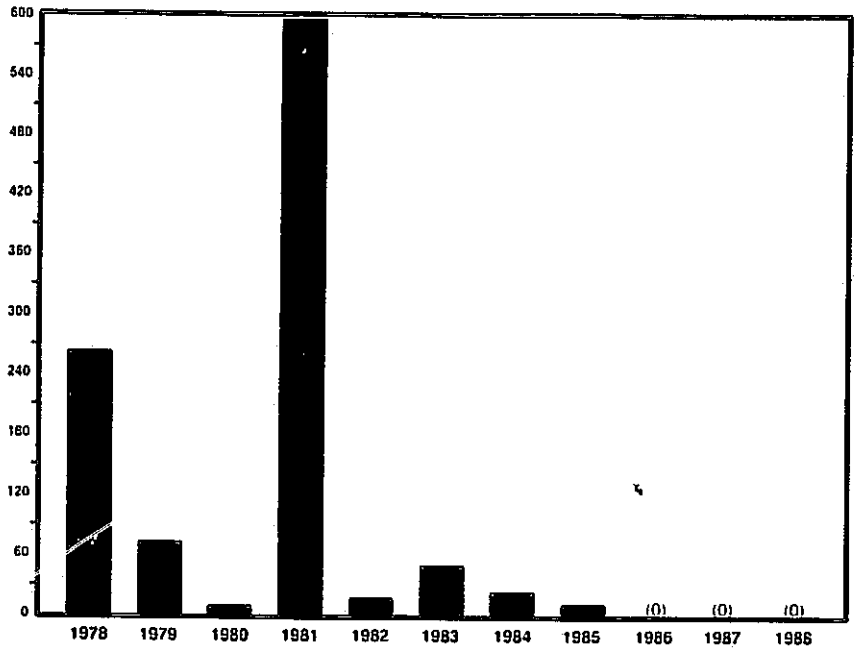
One of the benefits to NASA from a multiyear contract with ESPO is the continuity of operations that comes from using experienced personnel. This helps minimize program risk. The work force must be continuously vitalized, however, to maintain skills and stimulate improvements. Continuously recruiting new graduates and hiring senior specialized personnel has resulted in a balanced work force. Our practice of filling vacancies from within and then backfilling vacancies at the lowest practical salary grade has enabled us to control costs while providing an infusion of new talent.

Our commitment to improvement

Our initiatives in software utilization, automation, and artifical intelligence (AI) make up most of the submittals in our cost reduction program; in fact, 96 percent of the 1988 cost reductions fall into this category. These improvements are implemented on a project-by-project basis on individual job orders.

FIGURE 5

Number of location discrepancies discovered in annual lunar curatorial lab inventory, by year



A highly visible example of ESPO's expertise in software utilization is the mission evaluation workstation development and the reporting of this software to the Rockwell/Downey Sun workstations. This project, implemented in real time during the STS-26 mission, earned our team commendations from NASA.

Specific examples of software utilization facilitated by the Technical Information Processing System (TIPS) include:

- automation of drafting operations.
- integration of CAD/CAE on major projects such as the PCES project.
- use of a common computer data base to replace paper files such as our mechanical systems data base.

As part of the continued pursuit of improvement through software, we are evaluating the applicability of computer-aided software engineering (CASE) for the ESC. Currently, less than 5 percent of professional systems analysts in the United States have such an automated tool. An in-house productivity study involving 52 engineers from nine engineering departments shows that we perform a number of tasks on the ESC that could be improved by using a CASE tool. Data from the study indicate a potential productivity increase of 19 percent on software projects, with the largest improvements in configuration control, software documentation, and software maintenance. The use of CASE will also increase the quality of software products.

In order to gain maximum benefits from our software, our Information Services Section conducted a user survey and introduced a series of short courses, based on survey results, designed to enhance user productivity. These two- to four-hour courses, conducted during the workday, cover applications such as IPMIS, dBase, Wordperfect, and Lotus.

Automating many processes throughout the company enhances efficiency. Automation of the personnel requisition process is ongoing. In 1988 we automated the ALERT system for identifying and tracing hardware parts. Our system for controlling materials and supplies for six tool cribs was automated in 1987, and is operated by ESPO on-site. Bar-code scanning systems and related software were acquired to keep track of parts and other government-furnished equipment in ESPO's possession. Ten PCs were purchased to support the system. By automating this process, inventory now takes a few days instead of a few weeks.

We have developed AI applications related to system fault isolation and recovery, monitoring and control, and planning. Intelligent fault diagnosis systems developed by ESPO are applied to problems that range from analyzing communication network problems to isolating the failure of individual components on a printed circuit board. We are developing knowledge-based monitoring and control software for space station engineering test beds, shuttle simulators, and medical research systems. One system under development is the planning system for a mobile, autonomous robot developed to

evaluate concepts for a crew and retrieve equipment in space. Planning systems also have been developed for space station reconfiguration and management of the payload integration process.

Equipment modernization increases ESPO's productivity

"Leadership, as we intend it, includes several factors. A leader leads or is proactive rather than simply reactive. A leader innovates ways to produce the required results, however difficult the task, and enhances performance in all areas. Brilliant leadership includes breakthroughs in performance, as well as steady uptrends in performance."

—LESC President Bob Young Jr.

The implementation of TIPS (Technical Information Processing System) over a three-year period represents our largest individual effort in equipment modernization. TIPS consists of an operating network of computers, engineering workstations, PCs, word processors, and associated software and communication links specifically designed to increase the productivity of the work force. The system was developed to be compatible with the NASA-JSC computer systems. TIPS provides ESPO with an All-In-1 node on the NASA-JSC R&E network, a significant processing capability, added local area networks, and additional desktop CAD/CAE workstations. Word processing, engineering equations, and software programs are electronically integrated using TIPS, and electronic communication is available through the All-In-1 node. This allows two-way communication between NASA-JSC and ESPO. In 1988 we added a microwave link to our communications system so that the new Lockheed Plaza 4 could have efficient access to the VAX computing resources.

We define the productivity gain from TIPS as the added value derived from TIPS (based on our measurements) divided by the cost of TIPS to NASA-JSC, which is the cost of operations and maintenance. Based on measurements of drawings produced on our technical design and drafting system, connect time of our mechanical engineering and design system, use of PC workstations, and network activity of our electronic mail system, the total added value of TIPS to ESC is more than twice the cost of operations and maintenance.

In 1988, ESPO installed a new, modern ROLM PhoneMail system to improve responsiveness and communication with our NASA-JSC customer and within our organization. A computer-controlled message system, PhoneMail allows the NASA-JSC customer to reach ESPO employees with critical information and increases our responsiveness to requests. In addition, employees are able to give full attention to their work because the need to answer co-workers' telephones is eliminated. The system is expected to save about $3.8 million a year by reducing the time spent locating co-workers and taking messages.

Energy conservation provides savings

The Lockheed Plaza complex is an example of our initiative in energy conservation. These two modern buildings have a common energy management system—for lighting, heating, ventilation, and air conditioning—made by Staefa Control Systems (SCS). Thermostats throughout the buildings are monitored and controlled by a central computer. Staff personnel can easily diagnose and correct temperature variations with a few simple keystrokes. They can also set different temperatures for times when the buildings are not in use. This system controls energy use and reduces labor costs by centralizing and automating data collection.

The customer is satisfied

There is every indication that LESC ESPO is keeping the customer satisfied. We have been a recipient of the Johnson Space Center Team Excellence Award in both 1988 and 1989. The Team Excellence Award recognizes us for demonstrating outstanding dedication and commitment to quality and productivity in support of manned spaceflight. The awards have been presented personally by JSC Director Aaron Cohen and center Deputy Director Paul Weitz in ceremonies held at Lockheed Plaza 2. All employees were invited to the ceremonies to share in the celebration. LESC further rewarded its employees by conducting an after-hours celebration. LESC President Bob Young accepted the awards on behalf of the employees for their high quality products and services and for their leadership and commitment to continuous improvement. Other speakers at the event have included Virginia Thompson, NASA contracting officer; Marc Broussard, NASA ESC technical manager; and astronaut Karol Bobko.

Focus on the organization

Top managers prove they are committed to quality

If a company wants to successfully implement quality and productivity improvements and create an environment that fosters total awareness of such goals, its management must be committed for the long term. This is the case at LESC ESPO.

The oft-stated goal of LESC President R.B. "Bob" Young Jr. is "to be and be recognized as the service industry quality and productivity performance leader." Young's long-standing commitment to quality and productivity in the workplace is demonstrated by his participation in every annual NASA/contractor conference, as well as the 1984 and 1986 NASA National Symposiums on Quality and Productivity. He was a featured speaker at the 1986 NASA Symposium on Quality and Productivity in Washington, D.C. Young currently serves as the contractor co-chairperson for the NASA-JSC/Contractor Team Excellence Forum and speaks throughout the country about the importance of achieving quality and productivity gains in American business.

Young wants to develop leaders within the company. To do this, he created the Distinctions of Leadership course. The course, which is taught by Young, is open to all ESPO employees. NASA-JSC personnel are also invited. This seminar provides each participant with the unique opportunity to learn the company president's views on responsibility, accountability, built-in quality, and leadership. Top management volunteers support the Distinctions of Leadership program as coaches; these coaches are trained in a course titled Coaching for Superior Performance. The Distinctions of Leadership course establishes a proactive environment—one in which people seek innovative, creative approaches to work instead of sitting back and reacting to problems when they occur. This proactive, take-charge philosophy stresses building quality into all products and services. Since 1984, 348 Lockheed employees, including two-thirds of the managers, and 30 NASA-JSC personnel have attended the Distinctions of Leadership course.

Our managers are actively involved in productivity and quality efforts both within the company and in the NASA-JSC community at large. Our program manager, M.M. Miller, participates in the NASA-JSC Strategic Planning workshops on a regular basis. An ESPO director serves on the NASA-JSC/Contractor Team Excellence Forum's Strategic Planning Committee, and an ESPO manager is the chairperson of the Contract Incentives Committee of that forum.

Within the company itself, ESPO top managers actively plan, disseminate, and recognize our process improvement and quality enhancement (PIQE) attainments. Each director is responsible for at least one of our standing committees, which form the primary institutional structure for PIQE processes at ESPO. These standing committees meet monthly to plan, implement, and track progress on PIQE programs that implement ESPO long-range goals. Directors either attend the monthly committee meetings or receive a detailed briefing that is in turn reported on at the program manager's staff meetings.

To improve productivity, our management has strongly supported the establishment of electronic and computer networking. Widespread use of electronic messaging, automated personnel requisition and purchasing systems, and other such programs has become standard procedure at ESPO.

Perhaps the strongest sign of management's support for enhanced quality and productivity is the allotment of money and people. Over the last five years, ESPO has spent more than $6 million to implement projects initiated by employee teams. These projects include the development of the Artificial Intelligence Laboratory, the implementation of the Interactive Program Management Information System (IPMIS) for job order control, and the acquisition of TIPS. In addition, an ongoing, long-term management development program has been implemented to provide a common background of understanding for our management team. To accomplish this goal, a series of training programs that include productivity and quality policies and methods has been developed and implemented; 62 percent of the managerial employees participated in one or more of these courses in 1988. The management-development training budget for 1988 was increased by 5 percent over the 1987 budget, representing our capital commitment to ensure the quality and continuity of our management team.

In addition to the support given through the commitment of capital, our PIQE programs are supported through the commitment of human resources. Our Productivity Office, managed by an industrial engineer, provides a focal point for the development, implementation, and tracking of PIQE activities. In 1986, we created the position of the SR&QA Office manager, which had been a shared duty in the past. In addition, we increased the staff support in the SR&QA Office to meet the increased demands of ESC. This increase allowed us to assign SR&QA engineers to work with project teams in the design and development phase of hardware projects to ensure built-in quality.

Keeping track of PIQE goals

PIQE goals are communicated from the program and branch levels to operations managers and to their employees in many ways. Company newsletters and fliers, distributed to all employees, describe PIQE goals, projects, and rewards; they also publicize and describe classes, innovative activities, and cost-reduction efforts. In addition, announcements of special training sessions are carried on the Lockheed VAX system. Programs are also described and announced through interdepartmental communications (IDCs) and operations reports. All activities that improve quality and productivity are reported weekly in operations reports, which are sent regularly to each branch director and manager. Managers communicate pertinent information through a variety of other means, including electronic mail, department or section meetings, and goals set for each employee during the employee performance appraisal process.

"Communication is something different than taking turns talking; it's taking time to listen."

—Astronaut
Don Williams

PIQE goals and information are made known through various classes. Classes on TIPS, automated administrative systems, and productivity-improving software and hardware are offered to all employees. For new employees, orientation sessions serve as an important vehicle for disseminating PIQE information. To accommodate the constant influx of new people (about 10 per week), all new employees attend an initial orientation session on their first day at ESPO. Information is provided on the PIQE programs, and a point of contact is identified. The full orientation session is conducted monthly by top management and includes both a slide show of general information and an informal question-and-answer period.

Each year, company goals are set in the ESPO Performance Plan, an overall plan that establishes specific, measurable objectives for performance in the areas of finance, business, and organization. Even the most worthwhile goal is useless, however, without an effective means of implementation. Our established standing committee structure is the tactical mechanism for implementing improvement goals. This ongoing, standing committee activity is the primary means by which PIQE goals are stated, implemented, and tracked. Each standing committee has representatives from all levels: an ESPO director oversees it, an ESPO manager is committee chairperson, and committee members come from each branch. Standing committees include the following:

- College Recruiting
- Cost Reduction
- Employee Awareness
- Management Development
- IPMIS
- Safety
- Technical Training
- Technical Excellence

One example of the dynamics of standing committee action is the creation of monthly orientation sessions for new employees mentioned previously. The Employee Awareness Committee, a standing committee composed of employees at all levels, identified the need for the additional orientations, developed a new employee orientation handbook, and presented the plan to the directors for their approval. The directors approved the plan and implemented it; these top managers now work with committee members to present the monthly orientation. Other examples of PIQE accomplishments can be found in Table 1.

To ensure the enhancement of productivity and quality, it is not enough to formulate, implement, and promote objectives. Performance must be measured at every level to assess the program's effectiveness. The PIQE goals are part of the scorecard by which the program manager is evaluated at the corporate level. In turn, productivity goals are part of the criteria for appraisal of each manager within the program. The Employee Performance Appraisal program is used to assess employee performance. It is an ongoing process consisting of three phases: performance planning, performance monitoring, and performance evaluation. Through this process, employees receive ongoing feedback. Clarity of goals and accountability for performance are the two primary products of this process. The appraisal form includes a rating based on several different performance attributes, including leadership, progress in reaching productivity and quality goals, entrepreneurship, communication, and initiative.

For specific quality and productivity enhancement projects, standing committees and the Productivity Office develop performance measures and provide feedback to the affected organizations. We measured and documented engineering productivity in the six productivity studies that laid the background for TIPS, for example, and we are currently measuring the use and productivity of TIPS. We measure the efficiency of IPMIS on an ongoing basis. Our administrative Operations Department measures space utilization (square feet per person) and telephone trunk line use to track efficiency and effectiveness.

TABLE 1

1988 standing committees and PIQE accomplishments

Standing committee	PIQE accomplishments
College Recruiting	• Responsible for 740 on-campus interviews in 1988. • 166 job offers made; 67 accepted and were hired (40.4 percent).
Cost Reduction	• 50 employees received awards for verifiable submittals. • 1988 submittals totaled $11.2 million.
Employee Awareness	• Implemented a security awareness program. • Conducted the JSC Team Excellence Award ceremony and celebration.
Management Development	• Conducted a needs assessment survey. • Presented 7 courses, with 267 employees participating.
Interactive Program Management Information System (IPMIS)	• Task management – Improved system to review and determine disposition of change requests. • Finance – Evaluated financial data processes and reports. • Purchasing/Logistics – Developed a Support Contractor Purchase Request (SCPR) priority system. • Personnel – Automated the P-1 organization and approval process and the tentative employment offer process. • Security – Assessed compliance to Lockheed security guidelines.
Safety	• Conducted quarterly inspections of Engineering Support Contract (ESC) facilities and provided feedback. • Improved the storage method for flammable materials.
Technical Training	• Presented 26 courses to 481 participants. • Improved publicity through on-line listing of courses on the Lockheed VAX.
Technical Excellence	• Established a new technology review for Public Information Clearance (PIC). • Sponsored monthly technical forums and compiled the ESC Technical Excellence Plan.

Open communication promotes excellent performance

Because of our strong belief in the importance of open communication, we have a documented open door policy included in our management directives. This formal policy provides a means by which all employees, at their request, can obtain a formal review of their employment through discussion with their immediate supervisor, or higher supervision when necessary, with the counsel and advice of a member of the Employee Relations staff. This formal policy, however, is just the beginning. The open door policy is encouraged on a much more informal basis at all levels throughout ESPO. Managers meet freely and frequently with individuals and groups at all levels to discuss technical problems, productivity enhancement, cost reduction, employee morale, and career counseling.

A prime example of these open communications is the annual Top Management Night. It is conducted by the Lockheed Houston Chapter of the National Management Association (LHC-NMA), which is sponsored and strongly supported by ESPO. Any employee can submit questions, anonymously if so desired, which are then assigned to various members of top management. Every submitted question is addressed. Top Management Night is perhaps the most popular and best attended meeting on the annual NMA agenda.

Ethics training is yet another means we use to foster an environment of open and frank communication. Since 1987, more than 400 key personnel have attended a four-hour

ethics briefing. New employees also view an ethics film and attend a one-hour ethics orientation. The rationale behind company policies and procedures that have ethical ramifications is explained, thereby creating a foundation for open communications. Participants are encouraged to explore ethics issues for themselves through a series of discussions on actual and hypothetical situations.

"Today we see many businesses paying lip service to the importance of quality. What they fail to do is empower their employees to bring about quality improvement—to equip them with the tools, the training, and the thrust, and turn them loose to show what they can do. And when you're providing a service, this is perhaps the paramount determinant of quality."

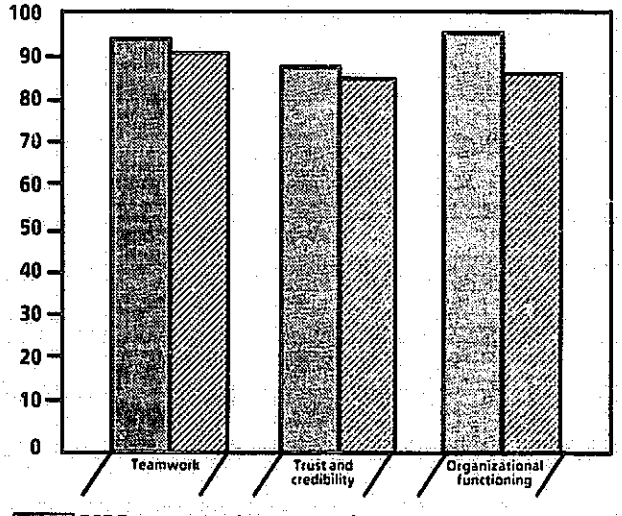
—Admiral Richard H. Truly
NASA Administrator

We also have a company hot line number, published in the telephone directory, that allows employees to raise any issue confidentially. Company policy establishes a specific evaluation process for each report.

Open communication is the foundation for the teamwork that enables smooth organizational functioning. How this concept actually works at ESPO was reflected in a survey conducted by the American Productivity and Quality Center (APQC). The survey was designed to identify and compare corporate culture attributes in companies that are widely recognized as excellent organizations. ESPO was one of 13 organizations chosen to participate. Employees responded confidentially to questions regarding teamwork and cooperative behavior within work groups, trust and credibility among managers and employees, and organizational functioning and the ability to get the work done. The positive ESPO responses, shown in Figure 6, exceeded the survey average, indicating that an environment of honest communication exists within ESPO.

FIGURE 6

Positive responses on corporate culture surveys



Training programs enhance performance

ESPO training programs and courses are designed to respond to a range of needs as broad as the services we provide. The program includes timely technical courses, ongoing laboratory training and certification, management skills courses, group process training, and personal development programs.

The technical training program offers a wide array of courses based on recommendations by the department managers and designated training representatives. The recommendations are formulated through an analysis of current and projected job requirements. Training opportunities are publicized through companywide memos and through an on-line listing of technical training information on the Lockheed VAX. The courses are conducted in-house and are directly related to the employees' work.

In fiscal year 1988, 26 courses were completed by 481 employees, the most employees ever to participate in such programs. The number of courses offered also reached an all-time high in 1988. This reflects ESPO's priority of training employees for current and future required ESC tasks.

The increase in course attendance is due, in part, to the 1987 change that allowed flexible work hours to accommodate education programs and training classes during the day. This flextime policy is coordinated by the employees' supervisors to make sure schedules are maintained and to make managers aware of employee education.

The Technical Excellence Committee sponsors forums on new and evolving technical capabilities so that achievements gained in one area of the ESPO program can be disseminated throughout the work force.

Personnel assigned to on-site laboratories receive certification training required for their specific operations area. On-the-job training is used in combination with lectures, study material, videotapes, and examinations to train lab personnel in a variety of techniques such as propellant handling, cryogenic fluids handling, and instrumentation. Laboratory personnel also undergo periodic refresher training and recertification (in most cases, annually), and specialized training on new hazardous material handling techniques and improved hardware testing and safety procedures. This training is conducted on an

ongoing basis, and each lab has strict guidelines on the training and certification required for all employees in the area.

ESPO realizes there is a critical need for people with superior management skills to properly manage highly skilled and diversified technical work. Therefore, we have implemented an ongoing, long-term management development program. This program provides a common background of understanding for our management team. To design the program to be responsive to the needs of managers and supervisors, we conducted a needs-assessment survey in 1988. It uncovered the need for 11 courses, seven of which were implemented this year. The remaining four courses are being developed. A total of 267 employees have completed one or more of these courses.

In addition, 334 employees completed 3,456 hours in 24 management and supervisory courses offered through the LHC-NMA from 1986 to 1988. These curricula included courses ranging from the first-line supervisory program to advanced management studies, as well as special topics such as understanding and managing stress.

Training in group process, problem identification, and solution training is included in several NMA and technical courses. Our project management course stresses a systems engineering approach to problem identification and solution, along with the value of the group process through brainstorming and participative decision making.

The majority of NMA courses are taught by ESPO employees. Managers are encouraged to teach these courses. For example, our director of management support leads the Situational Leadership Course. Because of the demand for the course, however, he has trained five additional course leaders from the management team.

Keeping employees healthy

In the belief that a healthy employee is a more productive employee, ESPO has created and made available programs that address personal well-being. We have a full-time center director who provides personal health counseling. Our facilities, located in Lockheed Plaza 1 and 4 buildings, include two aerobics rooms and a weight room. Personal development programs include 20 programs presented by the Lockheed Wellness Center in 1988, including seven health screenings with a total of 360 participants and lectures/workshops with a total of 251 attendees.

Educational activities are conducted on a continuing basis to create positive lifestyle changes regarding personal health. Classes are offered in nutrition, weight control, high blood pressure control, smoking cessation, biomechanical analysis, cardiopulmonary resuscitation, and stress management. Last year, 45 percent of our employees participated in at least one aspect of the program.

Our approach to occupational safety and health provides a uniform administration of our safety and health plan, which has been developed in accordance with the requirements of the JSC Safety Manual; NASA-JSC Instructions, Directives, and Policies Relating to Safety and Health of NASA; and applicable federal law. We recently initiated a comprehensive three-hour safety training course for all management and supervisory personnel. Specific training on hazards in the Thermochemical Test Area are taught in-house. The pre-employment drug testing program, which we instituted in 1987, emphasizes our concern for the well-being of present employees and our commitment to NASA to provide quality personnel.

"Successful space flight requires attention to detail." Overcoming the hostile environment of space "takes teamwork and total quality management. Lockheed has demonstrated that."

—Aaron Cohen
NASA-JSC Director

All levels are involved in PIQE

Our corporate culture focuses on a combination of employee participation and managerial support to solve problems and improve processes. The resulting teamwork that is ingrained in our standard operating mode is a reflection of ESPO's and NASA-JSC's commitment to achievement through team excellence. Team participation is such a normal part of work in ESPO that many teams operate without formal labels that identify their projects. Teams make no distinction between salaried and nonsalaried employees. Rather, we define a team simply as a group of employees who voluntarily join together in an effort over and above their normal work requirements. These teams submit and implement innovative ideas; initiate cost-reduction activities; and improve the quality and productivity of systems, processes, procedures, and products.

A total of 726 employees participated in 48 teams in 1988 (Figure 8). Using a baseline of 1,809 employees, this participation represents 40.3 percent of the work force. In 1987, 281 employees participated in teams; in 1986, 242 participated. The large increase in participation in 1988 is attributed to the maturation and stabilization of operations following the ESC transition. The large number of employees who were hired for the ESC have become acclimated to the ESPO team approach and their new jobs;

hence, they are now able to become involved in employee teams.

Employee involvement activities at ESPO are many and diverse. They range from highly technical work groups that develop sophisticated computer programs, to casual or entertainment-oriented groups such as the Houston Employees Recreation Organization, which promotes and coordinates the LESC dinner dance, the annual family picnic, and a variety of sports leagues and tournaments.

The formulation of specialist teams across organizational boundaries is a natural outcome of our project team approach to problem solving. For example, an improvement project that focused on travel operations involved employees who travel, secretaries, managers, and personnel from travel desk operations, accounts payable, information services, and headquarters. Likewise, a project to obtain and implement computer-aided software engineering (CASE) involved the collective efforts of 52 engineers from nine departments. Of 48 teams documented in 1988, 12 have members from more than one department.

Employees working together in a team committed to productivity enhancement often uncover opportunities to save significant amounts of money. The following is a partial list of PIQE projects implemented in 1988 that increased productivity and improved quality. Included are their estimated first-year savings.

- Solar Exploration Systems data conversion to compatible format, estimated savings: $2.01 million.
- SES simulation data transfer: $2.35 million.
- VAXPLOT, a plotting program for the VAX: $1.98 million.
- Still-frame digitization improvements: $476,600.
- On-line job order plan reporting: $841,300.
- Use of three-dimensional workstations: $484,300.
- Automated mission planning systems: $402,200.
- Automated purchase order system: $160,400.
- Orbiter mechanical systems data base: $78,000.
- Office supply automation: $33,500.

In 1988, 50 employees received awards for verifiable submittals totaling $11.2 million in cost savings. The total savings documented through this program since 1984 is $55.4 million.

FIGURE 7

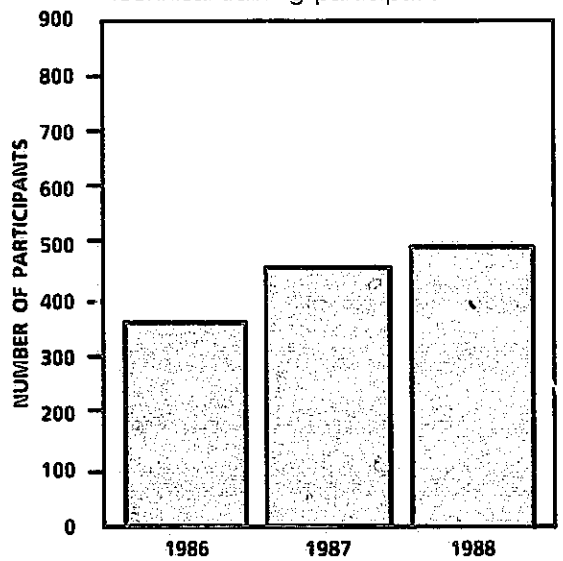
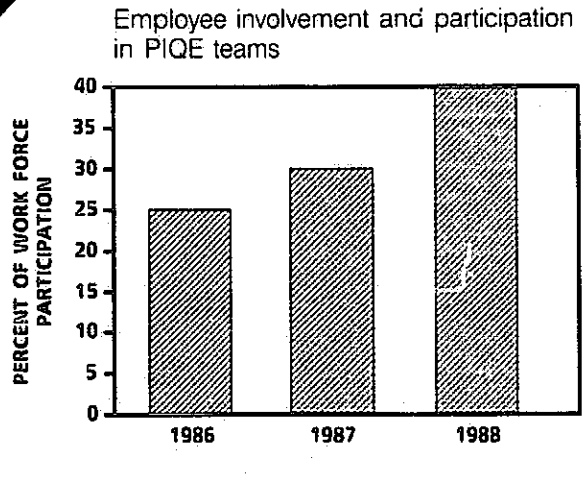


FIGURE 8



Employees receive meaningful rewards

ESPO provides a wide array of award and recognition activities. Recognition is based on contributions and achievements and can be given on any of the following bases:

- Individual. On an individual basis, 707 employees, comprising 39 percent of the work force, were recognized for their innovations and improvements in 1988.
- Work groups. Forty-three teams, comprising 37 percent of the work force, were recognized for team achievements in 1988.
- Organizational. Occasionally, work sections, entire departments, or all employees who worked on a particular project receive commendations for outstanding performance.

Recommendations from managers and branch directors, selection by our Cost Reduction Committee, and being published in technical journals form the basis for our in-company employee award/reward programs. Moreover, we often follow up employee recognition by our NASA-JSC customer

with ESPO commendations and awards. The following types of awards provide recognition to individuals and groups:

- The new technology program award. This cash award is presented for invention disclosures and new technology reports. New technology awards are given periodically, depending on the number of submittals. Four employees received these awards in 1988.
- The performance incentive program (PIP) award. Employees are rewarded with cash bonuses for outstanding work performance. The bonuses can be initiated at any level of ESPO management and must ultimately be approved by the program manager. PIP awards are given throughout the year.
- The publication award. This is a cash award to recognize an individual or a group for publication in a technical journal. Publication awards are given frequently throughout the year based upon publication acceptance.
- Letter of commendation. These letters, which recognize outstanding performance by individuals and groups, are usually based on recommendations by department managers and approved by branch directors.
- The cost reduction award. Administered by our Cost Reduction Committee, the cost reduction award recognizes individuals and teams whose efforts have resulted in significant cost reduction or cost avoidance. The Productivity Office verifies each submittal. Cost reduction award recipients are recognized at quarterly awards ceremonies. To enhance visibility of these achievements, the awards ceremonies in 1988 were held at on-site and off-site locations adjacent to the work environment of the award recipients so that co-workers and NASA-JSC counterparts could attend. Cost reduction rewards and recognition can be in the form of certificates of commendation, cash awards, U.S. savings bonds, desk sets, calculators, sports tickets, or gift certificates.
- Miscellaneous awards. In 1988, 391 employees were rewarded with sports tickets or restaurant gift certificates. Recipients are recommended by a department manager and approved by the branch director. The majority of the rewards are based on letters of commendation received from NASA. These miscellaneous awards are presented frequently throughout the year to recognize outstanding contributions as they take place. They are often presented at the program manager's weekly staff meetings.

In addition to in-company awards, ESPO participates in the competition for the Robert E. Gross Award for Technical Excellence, which is awarded yearly by the Lockheed Corporation. Each branch nominates a candidate, who must be a non-managerial engineer or scientist who demonstrates technical excellence. One or more names are selected as final nominees to represent ESPO, and these names are then submitted to the Lockheed Corporation for consideration. An ESPO nominee has won the award four of the seven years that the program has existed.

After LESC ESPO was selected to receive the 1989 NASA Excellence Award for Quality and Productivity, management decided that everyone's contribution should be recognized. A team of ESPO employees arranged a midday ceremony so that all could attend. Recognizing that our partnership with customers was and is crucial to success, JSC personnel were also invited. Nearly 3,000 people were bussed to the event, which featured top Lockheed and NASA management. After the ceremony, the entire crowd enjoyed a catered luncheon. Every ESPO employee received a quality and productivity lapel pin and a poster featuring LESC as the award recipient. The team of employees who arranged the event were rewarded with gift certificates and letters of commendation from the program manager.

> *"At Lockheed you have instilled a culture that challenges people to take responsibility for quality. And you have shown you can rise to the challenge."*
>
> —Admiral Richard H. Truly
> NASA Administrator

The Next Challenge

We at LESC ESPO continually strive to meet the challenge of improving the quality and productivity of our operations as a support service contractor. Our record of sustained excellent performance, coupled with a continuing innovation program, demonstrates top-down and bottom-up commitment to the role of service industry leader in quality and productivity.

At the award ceremony for the 1989 NASA Excellence Award for Quality and Productivity, Lockheed Corporation Chairman and CEO Dan Tellep reminded us, "We're not celebrating a graduation, a culmination, or completion of anything, because we know that quality is something which is enduring: a never-ending, continuous process." Along with Dan Tellep, we take this opportunity to "recommit to our intent to provide high-quality services to NASA in its mission, in its hopes, and in its vision for the future."

A unique aspect of the Second NASA Symposium on Quality and Productivity held in Washington, DC, in December 1986, was that attending organizations were invited to send teams of high-level executives as well as individuals. An outcome of this symposium was the development of seven strategies to guide and focus quality development efforts in succeeding years.

Leadership must commit to revitalization

Cultural change begins at the top with visible, valid commitment. Leaders must be active, persistent advocates of the need for change. At both the national and organizational levels, leadership is responsible for developing clearly defined goals and objectives to improve quality and increase productivity while creating an environment that enables change to take place. This includes re-educating the middle manager and fostering teamwork at all levels.

President Bob Young Jr.'s goal for ESPO is "to be and be recognized as the service industry quality and productivity performance leader." Young demonstrates his commitment to quality and productivity by participating in the Annual NASA/Contractors Conference and the NASA national symposiums on quality and productivity. Young currently serves as the contractor co-chairperson for the NASA-JSC/Contractor Team Excellence Forum and speaks throughout the country about the importance of achieving quality and productivity gains in American business.

To develop leaders within the company, Young has created the Distinctions of Leadership course. The course, which he teaches, is open to all ESPO employees. This seminar provides each participant with the unique opportunity to learn the company president's views on responsibility, accountability, built-in quality, and leadership. Top management volunteers support the Distinctions of Leadership program as coaches; these coaches are trained in a course titled Coaching for Superior Performance. The Distinctions of Leadership course establishes a proactive environment—one in which people seek innovative, creative approaches to work instead of sitting back and reacting to problems when they occur.

ESPO managers are actively involved in productivity and quality efforts both within the company and in the NASA-JSC community at large. They participate in events such as the NASA-JSC Strategic Planning workshops, the NASA-JSC/Contractor Team Excellence Forum's Strategic Planning Committee, and the Contract Incentives Committee of that forum.

Within the company itself, ESPO top managers actively plan, disseminate, and recognize productivity improvement and quality enhancement (PIQE) attainments. Each director is responsible for at least one of the standing committees, which form the primary institutional structure for PIQE processes at ESPO. These standing committees meet monthly to plan, implement, and track progress on PIQE programs that implement ESPO long-range goals. Directors either attend the monthly committee meetings or receive a detailed briefing, which is in turn reported on at the program manager's staff meetings.

Make quality integral to organization culture

A top-quality mentality is a requisite for organizational and product survival. It is an attitude that must be ingrained as a way of life for an organization—part of a philosophy that says: "When I pass my work on to the next person, it will be the best that I can do." It is the essential ingredient in a management culture that refuses to condone waste and is constantly looking for ways to make improvements. From the customer's perspective, it is the expectation of quality, the refusal to accept anything but the best. Quality performance should be recognized and rewarded by the organization.

ESPO corporate culture focuses on a combination of employee participation and managerial support to solve problems and improve processes. The resulting teamwork that is ingrained into the standard operating mode is a reflection of ESPO's and NASA-JSC's commitment to achievement through team excellence. Team participation is such a normal part of work in ESPO that many teams operate without formal labels that identify their projects. Teams make no distinction between salaried and non-salaried employees. Rather, teams are defined as employees who voluntarily join together in an effort over and above their normal work requirements. These teams submit and implement innovative ideas; initiate cost-reduction activities; and improve the quality and productivity of systems, processes, procedures, and products. A total of 726 employees, 40.3 percent of the work force, participated in 48 teams in 1988.

Employees working together in a team atmosphere and committed to productivity enhancement often uncover opportunities to save significant amounts of money. Three projects implemented in 1988 saved the organization more than $6 million during the first year alone. Another five projects generated average savings of more than $400,000 each. The total savings documented through this program since 1984 is $55.4 million.

A percentage of the savings is returned to ESPO individuals and work teams. On occasion, work sections, entire departments, or all employees who worked on a particular project receive commendations for outstanding performance. Awards range from cash and savings bonds to letters of commendation and companywide celebrations.

Focus on the customer

World class competitive organizations know their customers and are able to apply management techniques and organizational skills to provide what their customers want. They recognize that quality is what the customer needs. They work with their customers as partners throughout the product design, development, and delivery process. Focusing on both internal and external customers is an essential ingredient to an organization's future success.

A team of ESPO personnel and their NASA counterparts was called on following the STS 51-L accident to develop a shuttle crew escape system. Part of the system involved the newly designed launch and entry suit (LES). The LES project team was faced with three immediate problems: a short schedule, several large procurements, and a procurement organization not staffed for this type of activity. The organization of a flight procurement section, therefore, was the first step in meeting those challenges. The reorganization included separating purchasing, subcontract administration, and procurement operations. The Lockheed corporate resources were also utilized to meet special procurement problems. To further alleviate time and money constraints, ESPO and NASA made the decision not to subcontract the suit fabrication and integration task and to perform the final assembly in-house.

Because a short project schedule typically presents problems, project personnel met frequently. The project schedule became the focal point of discussions at weekly activity meetings held between the project engineer, the procurement supervisor, and the purchasing agent. During the most critical period, March through July 1988, meetings were held daily to coordinate and minimize negative redundant activities. Where unique problems so dictated, Lockheed corporate resources were used with the intent to make personal contact with the supplier to work out difficulties.

The ESPO project engineer gave the customer daily progress reports on the engineering and procurement action items. Problem areas were quickly and clearly identified through the use of color on the schedule chart. The straight-facts approach and clear project tracking aids helped direct customer-contractor actions quickly and efficiently. In the end, the ESPO SCES team delivered the suits on time and within budget.

Accept and manage change

Basic to improvement is the ability to change and adjust to competition and customer demands. Maintaining an entrepreneurial spirit and an openness to new technology and ideas requires management's ability to accept and manage risk. This is essential to fostering innovation and to carrying the fruits of innovation to a successful conclusion in the form of marketable products and quality services. Successful organizations are able to accept risk and manage change as a part of growth, understanding that focusing on long-range goals and having a vision for the future are more important than a preoccupation with the short-term bottom line.

Proof of ESPO's outstanding performance came in March 1987 when it was granted the Engineering Support Contract, the second largest contract supporting NASA-JSC. The contract covers an initial two-year period with three two-year options. The ESC consolidates the work previously done under separate contracts by three companies—ESPO, McDonnell Douglas Astronautics Company, and Northrop Services, Inc. Thirty percent of the ESC represented new work for ESPO, including support for the NASA-JSC Crew and Thermal Systems Division, Propulsion and Power Division, and Lunar Curation Laboratories.

Phase-in activities began immediately after the award announcement. To handle the increased work load, ESPO hired 95 percent of the incumbent work force from Northrop and 75 percent from McDonnell Douglas. By May 10, 1987, (well ahead of the targeted month of August 1987) 336 new people were brought on board. The quick work saved the government $5.3 million.

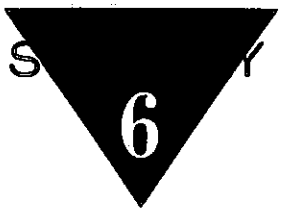
In the initial evaluation of the contract for the period ending July 1987, the NASA-JSC technical manager made special note of outstanding performance during the intense period of transition to the new ESC contract. ESPO performance was rated "high excellent." This work included the identification, recruiting, and hiring of the incumbent work force. Excellent progress in TIPS implementation and a continued high level of performance during the high activity transition period were also noted. Additionally, since the start of ESC, more than 400 letters of commendation for excellent performance have been received from the customer.

Establish a process to involve and recognize employees

Good communication throughout an organization is essential to the revitalization process and helps instill a sense of shared destiny in the work force. Employee motivation is the critical task associated with improving quality and productivity. Good communication and trust are essential to marshaling employee talents and capabilities to solve problems and allow continuous improvement to become an organizational way of life. Participative management should be encouraged in the organization and supported by ongoing management-employee training programs. It is particularly important that new programs are not perceived as undermining employee jobs or positions. Employee teams and suggestion programs, tailored to an organizational culture, stimulate involvement; they allow issues to be addressed by those who are closest to the problem.

Productivity Improvement and Quality Enhancement (PIQE) goals are communicated from the program and branch levels to operations managers and to their employees in many ways. Company newsletters and fliers, distributed to all employees, describe PIQE goals, projects, and rewards; they also publicize and describe classes, innovative activities, and cost-reduction efforts. In addition, announcements of special training sessions are carried on the Lockheed VAX system. Programs are also publicized in interdepartmental communications and operations reports. All activities that improve quality and productivity are reported weekly in operations reports, which are sent regularly to each branch director and manager. Managers communicate pertinent information through a variety of other means, including electronic mail, department or section meetings, and goals set for each employee during the employee performance appraisal process.

Each year, company goals are set in the ESPO Performance Plan, an overall plan that establishes specific, measurable objectives for performance in the areas of finance, business, and organization. Even the most worthwhile goal is useless, however, without an effective means of implementation. ESPO's established standing committee structure is the tactical mechanism for stating, implementing, and tracking improvement goals. Each standing committee has representatives from all levels: an ESPO director oversees it, an ESPO manager is committee chairperson, and committee members come from each branch.



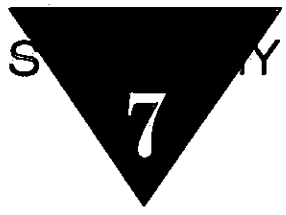
Measure activities to evaluate success

Achieving a top-quality culture within an organization requires continual, measurable improvements. Measurement is far more than keeping score. It is necessary for good communications and for focusing attention on priorities and on areas needing improvement. It provides for reinforcement of progress toward goals, and ensures and establishes accountability and an evaluation of how well one is doing. Measures are most successful when employees are involved in determining what the measures should be and how to achieve them—employee ownership is essential.

The effectiveness of ESPO innovations and continuous improvement are demonstrated by sustained ratings of excellent for cost, schedule, and technical performance in the award fee evaluation process since 1978 and also by the following accomplishments:

- Selection as the recipient of the 1989 Johnson Space Center Team Excellence Award. This marked the second consecutive year that ESPO received this honor.
- Verifiable cost reductions of $55.4 million since 1984. Each year has shown a steady increase in both the number of submittals and dollars saved.
- Continuing implementation of the Technical Information Processing System (TIPS), a network computer system to increase productivity and quality.

Open communication is the foundation for the teamwork that enables smooth organizational functioning. How this concept actually works at ESPO was reflected in a survey conducted by the American Productivity and Quality Center. The survey was designed to identify and compare corporate culture attributes in companies that are widely recognized as excellent organizations. ESPO was one of 13 organizations chosen to participate. Employees responded confidentially to questions regarding teamwork and cooperative behavior within work groups, trust and credibility among managers and employees, organizational functioning, and the ability to get the work done. The positive ESPO responses exceeded the survey average, indicating that an environment of honest communication exists within ESPO.



Emphasize education as a key to the future

A quality ethic and a highly productive society depend on an educated work force. To be competitive, organizations must be able to employ qualified people and then involve them to maximize their contributions and establish a basis for developing high-quality products and services. Thus, in a broader context, America must produce a talented, educated work force with the awareness and understanding necessary to function effectively and productively. Business must let the educational establishment know what it needs, and be willing to work closely with schools and universities to achieve it. Business and government leaders must support the upgrading of the nation's educational system.

ESPO's continual pursuit of technical excellence is reflected in course participation. About 27 percent of employees completed one or more of the 26 in-house technical training courses offered in 1988, 10 percent participated in the tuition reimbursement program, and 45 percent attended one or more of the 20 wellness center programs. Since 1984, 348 employees (including two-thirds of all managerial employees) have completed the Distinctions of Leadership course.

ESPO realizes there is a critical need for people with superior management skills to properly manage highly skilled and diversified technical work. Therefore, an ongoing, long-term management development program has been implemented. This program provides a common background of understanding for the management team. To design the program to be responsive to the needs of managers and supervisors, a needs-assessment survey was conducted in 1988. It uncovered the need for 11 courses, seven of which have been implemented. The remaining four courses are being developed. A total of 267 employees have completed one or more of these courses.

In addition, 334 employees completed 3,456 hours in 24 management and supervisory courses offered through the Lockheed Houston Chapter of the National Management Association from 1986 to 1988. These curricula included courses ranging from the first-line supervisory program to advanced management studies, as well as special topics such as understanding and managing stress.

Training in group process, problem identification, and solution training is embedded in several NMA and technical courses. The ESPO project management course stresses a systems engineering approach to problem identification and solution, along with the value of the group process through brainstorming and participative decision making.

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NASA would like to congratulate the following companies for achieving the status of Award Finalist for the 1988-89 NASA Excellence Award for Quality and Productivity. For more information on these companies, contact the representatives listed below.

Jerry A. Yglesias
Vice President, Operations
Barrios Technology, Inc.
1331 Gemini Avenue
Houston, TX 77058
(713) 280-1877

J. Jeanette Eads
Manager, Productivity
EG & G Florida, Inc.
P.O. Box 21267
Kennedy Space Center, FL 32815
(407) 867-7295

Monte Krauze
Director, PIQE Programs
Bendix Field Engineering Corporation
One Bendix Road
Columbia, MD 21045
(301) 794-3318

Jarvis L. (Skip) Olson
Program VP, Shuttle Processing
Grumman Technical Services Division
5195 S. Washington Avenue
Titusville, FL 32780
(407) 268-8400

Leroy Mendenhall
Manager, CMS Quality & Productivity
Boeing Computer Support Services
P.O. Box 5128, Ardmore Station
Huntsville, AL 35814-5128
(205) 544-4188

Sherry Prud'homme
Project Manager, Total Quality Management
Lockheed Engineering & Sciences Company
2400 NASA Road One
Houston, TX 77058
(713) 333-6200

Ted F. Pykosz
Manager, Productivity Programs
Computer Sciences Corporation
16511 Space Center Boulevard
Houston, TX 77058
(407) 867-2300

Charles O. Baker
Division Director, Product Assurance
Rockwell International Corporation
Space Transportation Systems Division
12214 Lakewood Boulevard
Downey, CA 90241
(213) 922-2093

For more information on program policy matters, contact:

Geoffrey B. Templeton
Program Manager, External TQM
NASA Excellence Award
Code QB
National Aeronautics and Space Administration
Washington, DC 20546
(202) 453-8415

For more information on award process and procedures, contact:

Craig A. Henry
ASQC Headquarters
310 W. Wisconsin Avenue
Milwaukee, WI 53203
(414) 272-8575

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